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Electric Lighting and Locomotion.*

BY PROFESSOR AYRTON, F. R. S.

In my last lecture, I explained why small current combined with great electric pressure or high potential must necessarily be used for economy in electric transmission of power, and why, therefore, the series working of lamps and motors was better than the parallel system. I went pretty fully into the consideration of what was necessary to obtain safety, and we found experimentally that two conditions were essential: the first, that both the going and the return wires should be well insulated from one another as well as from the earth; the second, that the current should be absolutely constant in its strength, and not merely have the mean constancy obtainable with many of the so-called constant current dynamos.

The very important problem of supplying constant electric pressure to the mains, however many lamps or motors were being fed by them in parallel, was next considered, as well as the problem of supplying constant current to motors or lamps in series, however many lamps or motors were being worked in one circuit.

We ended by considering the great importance of driving quick-moving tools like drills, fans, circular saws, etc., *directly* with electro-motors without intermediate gearing, because with such arrangement we saved, first, the loss of

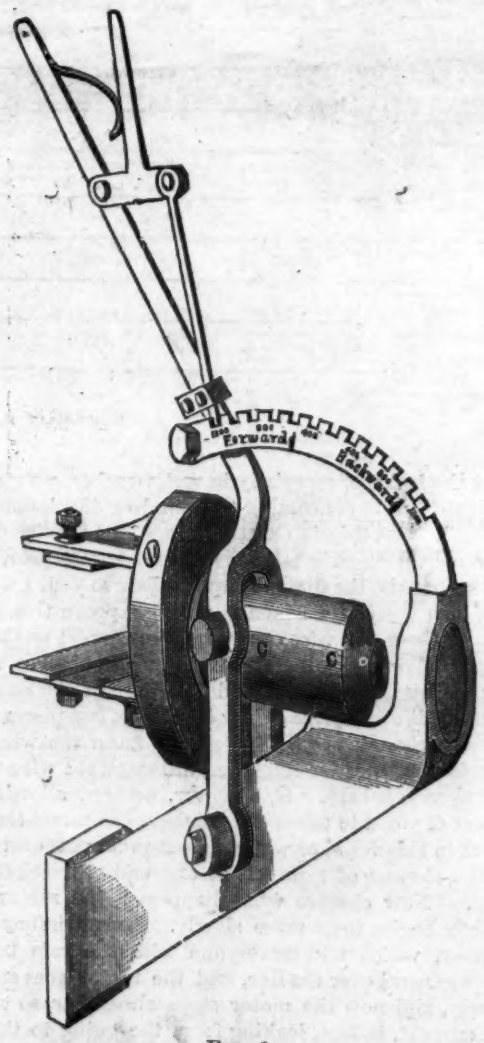

FIG. 2.

power that occurs in the shafting of a factory; secondly, the loss of power at the intermediate gearing employed to make the drill, or other quick-moving tool, revolve much more rapidly than the shaft, and, lastly, we secured the great convenience of being able to bring the machine-driven tool to the work instead of, as at present, the work to the tool. And there is one case where the driving of fans by electro-motors appears to me to be at the present moment of vital importance to us as citizens of London, I might almost say of national importance to us as Englishmen. For years past we have gone on breathing the foul air in the underground railway. Much grumbling has been the result, but hitherto no ventilation, and at the present moment we are contemplating, as a sort of final resource, the possibility of unsightly openings being made in the roadway of the embankment to let out the obnoxious gases. Now why do we not put fans at suitable intervals along the tunnel attached to quite small pipes for extracting the bad air? The fans could not, of course, be driven by steam-engines (there are steam-engines enough in the tunnel already), nor could they easily be driven by shafting or

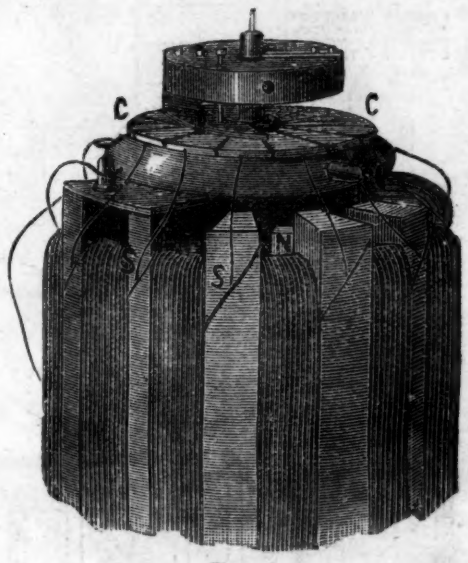

FIG. 1.

belting, but an electro-motor attached *directly* to each fan would furnish the driving power without introducing any inconvenience whatever. No gearing would be necessary, a single insulated going and return wire would convey from motor to motor the electric power produced by a large dynamo outside the tunnel, and a steam-engine might puff away in some back yard, out of everybody's way, and give us perfect ventilation on the underground railway.

And when on the subject of electro-motors, I explained that Professor Perry and myself had been led to construct electro-motors on a different principle from that usually adopted. In a dynamo machine there are two electro-magnets, and the machine acts as a producer of electricity, because the work that is necessary to be done to move one of the magnets relatively to the other to overcome their attractions and repulsions is turned into electric energy. In practice one of these electro-magnets is usually kept at rest, while the other is in motion. In one of them the current always flows in the same direction, while in the latter it is constantly being reversed in direction. The former is called the "field" or inducing magnet, while the latter is the "armature." Now it can be shown that in every dynamo-machine the magnetism produced by the current flowing round the armature must necessarily weaken the magnetism produced by the current flowing round the field-magnets, and hence must necessarily diminish the power of the dynamo.

Hence the best dynamos have been so designed that while the exciting electro-magnets form a very strong magnet, the armature only produces a very weak one. This result has been arrived at partly by making the armature of a dynamo small, compared with the field electro-magnets, and partly by giving it a squat form; and because the field magnet is large, it is, as a rule, kept stationary, while the armature revolves inside its poles.

I went on to explain to you that Professor Perry and myself had concluded from certain theoretical and practical considerations that in an electro-motor, on the contrary, the strengths of the two magnetic fields produced respectively by the field-magnet and by the armature should be equal, since the one, so far from weakening the other, can be made to strengthen the other; and since the armature from its shape is necessarily rather a weak magnet, whereas the field, or exciting magnet, from its shape is a strong one that we had reversed the usual condition of things and made the armature large and the field-magnet small, and that from this we had been led to make the armature stationary and surrounding the field-magnet, instead of, as is usual, the field-magnet surrounding the armature.

Our small field-magnet, then, carries the brushes and revolves inside the stationary armature, the coils of which are joined to the stationary commutator C C, Fig. 1, which, unlike ordinary commutators, we make flat to save both space and expense.

Wherever the brushes B happen to be at any particular moment, there two opposite magnetic poles are produced on the armature, as shown in Fig. 1. As the brushes run round and round so do these poles, and the brushes which, be it remembered, are carried by the field-magnet, are so set that the magnetic poles in the armature are always a little way in front of those in the field-magnet. The latter, therefore, are perpetually running after the former, but never catching them.

The law connecting the power of electro-motors with their size I dwelt on, and I explained that if the length, breadth and height of a motor be doubled so that its weight and cost become eight times as great as before, its power is about 20 times as great as before, and its efficiency or the ratio of useful power given out to electric power put in is also much increased.

I ended my lecture by referring, but from want of time only very briefly, to the governing of motors. An ordinary ungoverned motor goes very much faster when running

FIG. 4.

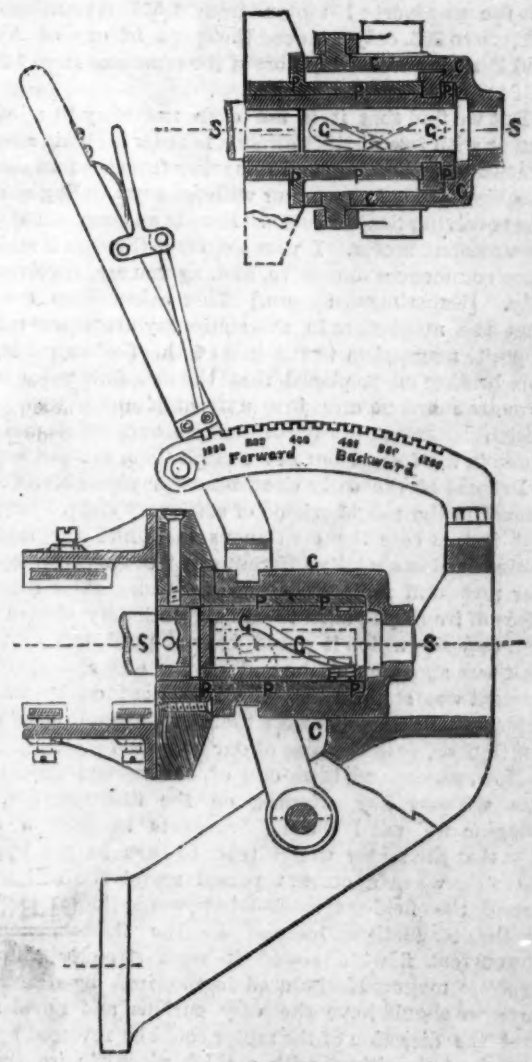

FIG. 3.

empty than when there is a load on, but in practice it would never do for a piece of wood or iron in a lathe to rush round when the chisel was taken off, since not only would there be a great waste of power but on next applying the chisel it would be probably broken by the wood or iron when rotating with such an excessive velocity.

*Lecture II., delivered at the London Institution, March 15, 1883.

Not only, then, must we arrange in the way I described, that the supply of electric power is proportional to the demand but also that the motors consume this power in proportion to the work they have to do; in other words, the electro-motor must be governed so as also to run at the same speed, whatever amount of work it may happen to be doing. I referred to the oldest form of governor for motors, which I have called the "spasmodic governor," and which I will now show in action. [Experiment shown and full explanation given.] The great objection to it is that it either supplies full power when the motor is running too slowly, or no power when it is running too quickly, and therefore cannot produce a constant speed. Our "periodic governor," which never supplies full power or no power, but always an amount of power exactly in proportion to the demand, I very briefly referred to, and which I will now describe to you more in detail, [Ayrton and Perry's "periodic governor" shown in action and fully explained*]; and lastly I referred to the most advanced system of governing motors, which we had arrived at by winding the motor with two distinct circuits in such a way that the current passing through one of them magnetizes the iron, causes the machine to act as a motor, and consequently is itself resisted, whereas the current passing through the other circuit tends to demagnetise the iron and stop the motion, and consequently is itself helped on; in fact we have combined a motor and a dynamo in one machine, and so have dispensed altogether with anything of the nature of a mechanical governor. In the spasmodic, as well as in our periodic governor, the regulating action is produced by the supply of power being cut off when the motor is beginning to go too fast, but in our combined motor it is usefully employed to reproduce electric energy, which is added to the supply in the main circuit. In the one case, when less work has to be done by the motor, less electric power is given it, while with our combined motor the supply always remains the same, but when much work has to be done by the motor, nearly all the electric supply is turned into useful mechanical work; whereas, on the other hand, when little useful work has to be done, a portion of the supply, after being turned into kinetic energy, is reconverted into electric energy, and added to the supply going to other motors. The difference in principle is of this nature: the periodic governor corresponds with a man who, when he has not much work to do, does not eat much—lives economically, in fact; whereas our combined motor corresponds with a man who always eats the same amount every day, but when he has little work to do on his own account, immediately goes and helps somebody else who is hard pressed with work. [Experiments were then shown with the combined motor, and it was proved that the change of load which diminished the speed of the ungoverned motor from 1,560 revolutions per minute to 508, only reduced the speed in one of Ayrton and Perry's governed motors of the same size from 1,250 to 1,184 revolutions per minute.]

But we find that it is not even necessary to wind the motor with two distinct circuits in order to obtain a certain amount of governing, and this arises from the fact that our machine will act as a motor without any winding at all on the revolving field-magnets. Here is an example of such an unwound motor. I pass a current through it and it at once commences to revolve, and, as you see, revolves rapidly. [Experiment shown.] This arises from the fact that the magnetism in the stationary armature induces opposite magnetism in the iron of the field-magnets, and the brushes are so placed that the magnetic poles in the armature are always just in front of those in the iron, which latter are always running round and round after those in the former but never catch them up.

In some of the early electro-motors pieces of soft iron moved in the neighborhood of stationary electro-magnets, but in that case the continuous motion of the iron was maintained in a totally different way from that employed in our unwound motors, because in those older motors a piece of iron was pulled towards a stationary electro-magnet, opposite which it would have stopped, but that just as it was approaching the end of the electro-magnet the current was stopped and the iron went on by its own momentum; the pulls were therefore intermittent and not continuous, as in the case of our unwound motor.

Now, suppose we have one of our motors adjusted to run without any winding on the field-magnets, and imagine we wind the field-magnets in such a direction that the motor would tend to turn in the opposite direction when a current passed round the coil wound round the field-magnets, what would happen? Why, if the magnetism induced in the field-magnets by the current flowing round it were stronger than the opposite magnetism induced in the iron by the armature we should have the very curious and novel result that the direction of the motor could be reversed by simply short-circuiting, with a thick piece of wire, the current flowing round the field magnets, and this result we have practically attained, as I will now show you. [Experiment shown.] Allow the current to flow through the armature and field-magnets and the motor runs one way; let it only flow through the armature alone and the motion is instantaneously reversed. Merely pressing down the key, then, reverses the motion. Hitherto the much more complicated arrangement of reversing the electric connections between the armature and field magnet had always been thought necessary to reverse the direction of motion of a motor.

We have in the preceding considered that the magnetism produced by the coil on the field magnets was greater than that produced by the induction of the armature itself, and so determined the direction of motion. But suppose that is not the case, then what will happen? Why, in that case the current passing through the coil on the field magnets will be resisting the motion, and so will be helped on. But that, as we saw before, is exactly the condition necessary for governing. The armature then and the iron of the field magnets act as a motor, while the armature and the coil wound round it act as a dynamo, and if the resistance of the coil, which we make of fine wire, and as a shunt to the armature, is of proper resistance, so that the required speed the motor is run at is the critical speed of the dynamo, the governing of our motor may be fairly perfect with only one circuit on it.

Hitherto we have been dealing with motors especially intended always to run at one speed, whatever amount of work they might be doing. We next come to motors for electric tram-cars, tricycles, etc., designed to run at any desired speed forward or backward.

I have spoken about the set of the brushes relatively to the field magnet, and the set, or "lead" as it is technically called, is of great practical importance, since on the amount of lead depends which way the motor revolves, or whether it revolves at all. Although the fact that the direction of rotation could be reversed by a sufficient change in the lead was well known, the importance of varying the lead in motors for different speeds appears to be little attended to, since it is impossible as a rule in motors, from their construction, to make small changes in the lead. In our motors, on the other hand, the flat brush-holder can be revolved forward or backward by hand through any angle, so that any lead forward or backward can be given to the brushes for each speed, and in our larger motors, of which I have a sample here, the lead can be made anything we like simply by moving a handle, such as a locomotive engine-driver is accustomed to use for acting on the link-motion of his engine. Push the handle shown in Figs. 2, 3, and 4 forwards, and the motor revolves rapidly in one direction; pull it backwards, and it revolves as rapidly in the other direction. Push it not so far forwards, and it does not revolve so fast in the first direction; pull it not so far backwards, and it does not revolve so fast backwards. In fact, by moving the handle forwards or backwards any speed, in either direction is obtainable. The action of our "lead adjuster" is as follows: Attached to the rotating field-magnet is the spindle, S S, which is itself attached to and rotates with the outer collar C C. On pushing the handle forwards or backwards this collar is moved along the spindle, and the effect of this is to cause a pin to move along the groove G G and so cause the inner collar P P, which usually rotates along with C C and the field-magnet, to move a little forward or backwards relatively to C C. Now it is the collar P P which is screwed to the brush-holder, hence we are able, even when the motor is running, to shift the brushes relatively to the field-magnet together with which they are rotating, and consequently with only *one pair* of brushes to give any lead forwards or backwards we desire. In other cases we alter the lead by means of a wheel and screw, and so get very easily a very accurate adjustment. A table of speeds can be engraved showing the position the handle should be in for 500 revolutions a minute or 700 revolutions a minute, &c.

On the last occasion I showed you photographs of all the principal electric railways, and we saw that in some cases the current went by an auxiliary insulated rail, passed through the motor under the train, and came back by the rails. In other cases both the going and return wires were of the nature of stout overhead telegraph wires, and a running connection between the motor on the tramcar and these wires was kept up by two small jockeys, that were pulled along the telegraph wires by wires attached to the tram-car. In a third system, the going and return conductors were simply ordinary rails on which the train runs, the insulation produced by the rails merely resting on wooden sleepers having been found sufficient for a length of one or two miles. As you will see from the photographs that I now project on the screen, this last and simplest plan has been adopted for the Portrush Railway, near the Giant's Causeway, in Ireland. This electric railway, Mr. Trail (the chairman) has been so good as to write to me, "runs on a footpath, or trampath, by the side of the road, which has been widened for the purpose from 24 to 27 feet. The path is 7 feet wide, leaving 20 for the carriage-way. We first tried," he says, "sending the current by one rail, returning by the other rail, after passing across by the car, and for this purpose had laid the rails in asphalt with thick felt underneath, but we found that the leakage, especially in wet weather, was too great to justify us in continuing that kind of insulation for six miles." Now this is exactly the result I predicted in my lectures on electric railways delivered last year, and in order to make the difficulty quite clear to you, I will show you the experiment I then showed to prove this. A portion of the going wire conveying the current working that motor driving the circular saw is, as you observe, wrapped round this bit of wood, and a portion of the return wire round this other piece of wood. As the two pieces of wood are dry, there is very little leakage from the wire on the one to the wire on the other, although the wire wrapped round each is bare. If, however, without allowing these pieces of wood to touch one another, I immerse the ends of them in this vessel of water, I shall produce the same effect as if a shower of rain fell at one end of the electric railway. Now observe what happens: the motor immediately begins to go more slowly. Let me immerse them further, which will correspond with the rain becoming more general over the line, and the motor goes still more slowly, and now the motor stops altogether, so much of the current, in fact, leaking from the going to the return wire through the water that sufficient does not pass through the distant electric motor to keep up its motion.

How then has this difficulty been overcome at the Giant's Causeway. Mr. Traill's letter tells us. He says, "We have therefore placed a third rail of iron on wooden props close into the fence, so that a brush sticking out from the car on a steel bar runs along the top of this third rail, which is about 15 inches from the ground. He goes on to say that this third rail is embedded in tar on the tops of the posts, and that when in addition pieces of the new insulating material, 'insulite,' are introduced between the rail and the wooden posts they expect the insulation will be perfect. He adds: "At present we can run for over two

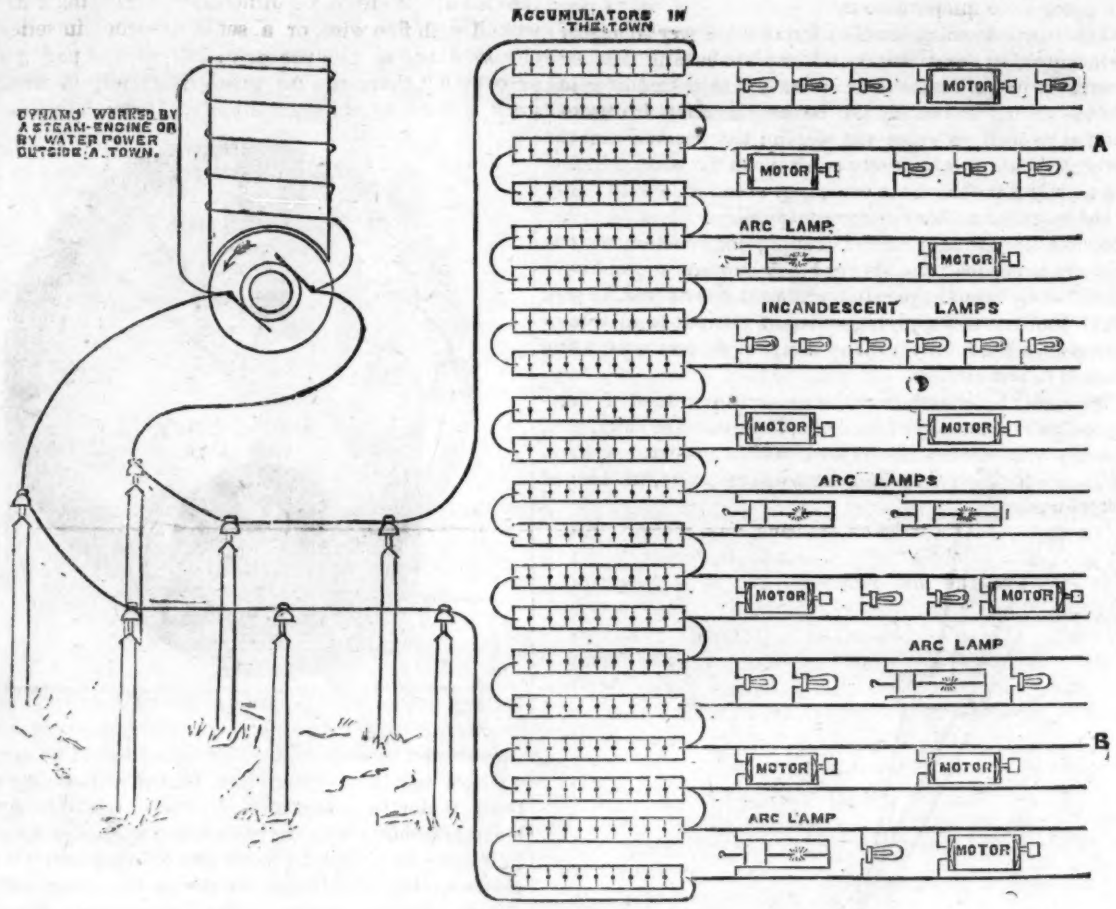

FIG. 5.

* See page 182, OPERATOR AND ELECTRICAL WORLD, March 24, 1883.

miles on the road up and down hill gradients as great as 1 in 35. We took six tons up that incline the other day. We are about to erect turbines at the Waterfall above Bushmills, which will give us from 60 to 100 horse-power, and will generate the current there about half a mile from our main line at Bushmills. We have powers by the Act of Parliament to construct a railway from Bushmills to Dervock, inland about seven miles, almost at right angles to the line of tramway on the sea coast. As the waterfall is near the junction of railway and tramway we intend to use it for the railway as well, as the works will do for both. We are limited by an act to 10 miles an hour on the tramway, but will have no difficulty in going to 20 or 25 miles an hour on the railway, which has also the advantage of being level the entire way."

But although they have succeeded at Portrush in overcoming the difficulty of leakage by using this third insulated rail, resting on posts 15 inches above the ground, such a system presents, you will easily see, great inconveniences for ordinary railways, since at every crossing there would be this raised rail in the way of the trains, and an even greater objection is the risk that it introduces, that any one can, from carelessness or malice, by resting, say, a crowbar against this raised insulated rail, send all the electricity to the earth and so cut off all electric power from all the trains either in front or behind.

On the other hand, the plan of using stout telegraph wires, with running jockeys to keep up continuous electric connection between these wires and the moving trains, would present great mechanical difficulties if the trains were going at 60 miles an hour.

What, then, do we propose? Professor Perry's and my plan is shown in the pictures in your hands, and is this: we electrically subdivide the rubbed rail into a number of sections all fairly but by no means perfectly insulated from the ground. We do not apply our electricity directly to this rubbed rail but, instead, to a well-insulated conductor, which may be buried underground or may be insulated by resting like a telegraph line on insulators on posts, and we arrange that whenever a train enters on to any section, it automatically makes an electric connection between that section of the rubbed rail and the well-insulated conductor which supplies the power, and at the same time automatically cuts off the electric power from the section the train has just left, and in this way we confine the leakage of electricity to that section on which the train is at any particular time, and so reduce the leakage and waste of power on the longest electric railway to less than it is at present on the shortest line constructed on the Berlin plan.

But not only does a train on entering any section automatically turn on the electric power to that section and cut it off from the one just left, but it accomplishes something more: it blocks absolutely the section just left. Let us take an example: Suppose a train is passing from section *A* to section *B*, then not only is the power automatically turned on to section *B* and cut off from section *A*, but no following train entering on section *A* can receive power and move on as long as the train in front is on section *B*. It is not until the preceding train has passed into section *C* that the following train can proceed along section *A*. And, in addition, whenever a train is approaching too near a train in front and in consequence finds itself deprived of driving-power, it is, by a special plan we have contrived, automatically powerfully braked.

Whenever, then, a train—it may be even a runaway engine—enters on a blocked section not only is all motive power withdrawn from it, but it is in addition automatically powerfully braked quite independent of the action of signalman, guard, or engine-driver, even if either the latter two men be present, which, bear in mind, is not at all necessary with our electric railway. No fog, nor color blindness, nor different codes of signals on different lines, nor mistakes arising from the exhausted, nervous condition of overworked signalmen, can with our system produce a collision. The English system of blocking means merely giving an order to stop, but whether this is understood or intelligently carried out is only settled by the happening or non-happening of a subsequent collision. Our absolute automatic block acts as if the steam were automatically shut off and the brake put on whenever the train is running into danger; nay, it does more than this, it acts as if the fires were put out, and all the coal taken away, since it is quite out of the power of the engine-driver, if there be one, to re-start the train until the one in front is at a safe distance ahead.

At present much household work is done by hand, simply because there are no easily worked machines for doing it. The old knife-board has given way to the rotary knife-cleaner, but even that requires a certain amount of grinding to give the knives a polish, so that for large establishments a knife-cleaner boy is still necessary. The blacking of boots, the blacking of grates, the cleaning of doorsteps, etc., are all done in a most laborious way by hand. (I might almost say the operation seems not to be confined to hand, judging from the general smutty appearance of Sarah Anne after the process.) Now, there can be no doubt that very shortly electricity will be supplied, as gas is now supplied, to houses for lighting purposes, and when this has been accomplished the same wires that convey the electricity for lighting can in the day convey the power to work electric motors to turn rotary knife-cleaners, to turn a wheel for the blacking of boots, and a small motor carrying a brush like the one in my hand will simply be passed by the servant all over the grate for the purpose of giving it a good black polish. The black-lead brush will then be taken off, and replaced by the blacking brush for the boots, and later on in the day a rotary flannel will officiate for the door-steps.

The high price of land in towns necessitates gas-works being in the suburbs, so in the future the electric works must be in the country, and probably farther away from the towns than even gas-works are at the present time, because not only will great economy be so attainable, but the town will be freed from the smoke of the engines to drive the dynamo machines or producers of electric current, and by that time we shall have begun to realize that a smoky atmosphere is a poisonous atmosphere; further, if our dynamos are far away in the country advantage can also be taken of natural sources of water-power.

The transmission, then, of power by electricity is not only a problem which must be solved, but is one which calls for immediate solution.

For the economic electric transport of power we must produce, as I have explained, a great difference of potentials by a dynamo at the place where the power is obtainable—in the suburbs where, for example, is the steam-engine or water-wheel—and employ some mechanism which can be worked by this great difference of potentials at the place where the power is to be utilized—that is, in the town. There is no difficulty in arranging a dynamo wound with fine wire, or a set of dynamos in series with one another, to produce any difference of potentials required; but there is a far greater difficulty in using this great difference of potentials at the town end of the line.

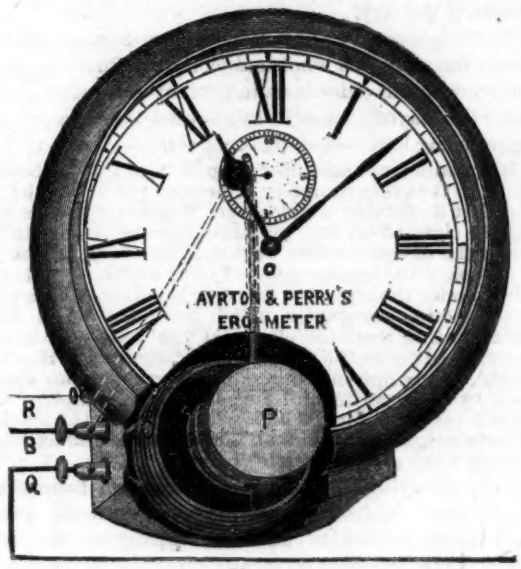

FIG. 6.

If lamps and motors of the present construction are used they would have to be put in series, but in that case if the current is stopped passing through one it will be stopped passing through all. This difficulty can to a great extent be avoided by using "cut-outs," as I described to you in my last lecture. At the same time nobody would be perfectly satisfied that his supply of electric power should depend on the good working of all the electric apparatus in the same street, much less that it should depend on the good working of all the electric apparatus in the same town. We are content that our supply of gas or water should depend on the good working of the gas or water-works, but we could not tolerate the possibility of Betsy Jane, in Moorgate street, from some carelessness or other, being able to cut off our supply at the London Institution. That Jack Frost should stop our supply is bad enough, but Betsy Jane—no!

What, then, are we to do? High difference of potential we must use, and we cannot work the lamps and motors in parallel unless they have a resistance of tens of thousands of ohms, in fact, are of a totally different description from the lamps and motors of the present day. The solution was first suggested by Sir William Thomson in 1881, and, I am happy to say, will very shortly be carried out by Prof. Perry and myself in Paris, under the auspices of the French Electrical Storage Company. It is to use the small current and great difference of potentials to charge a very large number of accumulators, in series, in the town, and to discharge them in sets, as shown in the figure, each set supplying the energy for one street, or, possibly, for one district. Of course, the going and return wires between the dynamo and accumulators must be separately insulated and put so far apart that there is no fear of a man or an animal accidentally touching both. If, in addition, it is feared that although this precaution is taken still somebody may touch a leading wire, say, *a*, coming from somewhere near one end of the accumulators, while another person may accidently touch a leading-wire, *b*, coming from somewhere near the other end of the accumulators and so both receive a fatal shock, this may be also entirely avoided by electrically disconnecting the various sets of accumulators from one another and from the

(*Continued on page* 197.)

Fundamental Principles of Electricity.

BY P. H. VANDER WEYDE, M. D.

IV.

The remarkable fact (brought forcibly to light by the experiments described in the former article) that the two opposite electricities neutralize one another when united, is the foundation of the theory that *all bodies possess naturally these two electricities, which show themselves only when they become separated.*

The different agencies by which this separation may be effected generate various forms of the two electricities, of which the first and most simple is produced by friction. It is this form which we consider first in this series of articles, because it produces the most tangible electricity best adapted for the study of its properties. For this reason, it was the first form to be discovered and experimented upon. By itself it is of comparatively little practical utility, but it has opened the door to the knowledge of other more useful forms which, without the preparatory study of frictional electricity, would forever have remained undiscovered.

That the friction by which we obtain electricity does actually separate the two kinds which neutralize one another in all bodies, is proved by the fact that if the rubbed body becomes positive electric the rubber becomes negative, and *vice versa*.

THIRD SERIES OF EXPERIMENTS.

This separation of the two electricities by friction can be shown by those friction electric machines in which the rubbers are insulated. They show that while the glass becomes positively charged the rubber will be found to have become negative. Without the possession of such a machine, it may be shown by insulating the piece of bronze powdered leather used for rubbing the glass rod; this is easily done in separating it by several thicknesses of silk or very dry wool from the hand which holds it, and taking care to discharge frequently the positive electricity from the glass, so as to prevent the communication of it to the leather. Very soon the latter will possess enough negative electricity to show its nature upon one of the electroscopes described on page 179 of our former number. (Attentive readers will have noticed an error in the numbering of the figures on page 179, Fig. 5 being the gold leaf electroscope, Fig. 6 the straw electrometer and Fig. 4 the electrometer of Coulomb; substituting those numbers, the explanation in the text will refer to the right figure).

Experiments have shown that it is not absolutely true that glass always becomes positive electric, nor vulcanite, or sealing wax, negative. This depends upon the substance with which it is rubbed. When glass is rubbed with cat's fur it becomes negative, and when vulcanite is rubbed with bronze powder it becomes positive. The reason is that cat's fur is the most electro-positive of all substances, while the noble metals are the most electro-negative, consequently cat's fur and also wool will make any substance rubbed with the same negative, while noble metals will make them positive.

As it is not practical to rub glass effectively with a piece of metal, a metallic paste used to be employed, by making an amalgam of mercury, tin and zinc, mixing this with tallow and applying it to the leather rubber of electric machines. As in the course of time this mixture dries out, becomes hard and may scratch the glass, well informed electricians have abandoned its use for the sulphuret of tin.

That the friction of a solid and a liquid may also develop electricity, is proved by a machine made by Van Marum, in which a disc of shellac was, with its lower edge, dipped in a bath of mercury. By the rotation of the disc, the mercury and the disc became charged with opposite electricities.

Cat's fur and negative metals being the two extremes for the development of positive and negative electricities by friction, the question may be asked if a table may not be constructed showing the relative position of bodies in regard to these properties, similar to the table we gave on page 165 for conductors and insulators. We give here such a table, which shows how, when two bodies are rubbed together, the preceding one will be positive and the following negative electric.

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Not only, then, must we arrange in the way I described, that the supply of electric power is proportional to the demand but also that the motors consume this power in proportion to the work they have to do; in other words, the electro-motor must be governed so as also to run at the same speed, whatever amount of work it may happen to be doing. I referred to the oldest form of governor for motors, which I have called the "spasmodic governor," and which I will now show in action. [Experiment shown and full explanation given.] The great objection to it is that it either supplies full power when the motor is running too slowly, or no power when it is running too quickly, and therefore cannot produce a constant speed. Our "periodic governor," which never supplies full power or no power, but always an amount of power exactly in proportion to the demand, I very briefly referred to, and which I will now describe to you more in detail, [Ayrton and Perry's "periodic governor" shown in action and fully explained*]; and lastly I referred to the most advanced system of governing motors, which we had arrived at by winding the motor with two distinct circuits in such a way that the current passing through one of them magnetizes the iron, causes the machine to act as a motor, and consequently is itself resisted, whereas the current passing through the other circuit tends to demagnetise the iron and stop the motion, and consequently is itself helped on; in fact we have combined a motor and a dynamo in one machine, and so have dispensed altogether with anything of the nature of a mechanical governor. In the spasmodic, as well as in our periodic governor, the regulating action is produced by the supply of power being cut off when the motor is beginning to go too fast, but in our combined motor it is usefully employed to reproduce electric energy, which is added to the supply in the main circuit. In the one case, when less work has to be done by the motor, less electric power is given it, while with our combined motor the supply always remains the same, but when much work has to be done by the motor, nearly all the electric supply is turned into useful mechanical work; whereas, on the other hand, when little useful work has to be done, a portion of the supply, after being turned into kinetic energy, is reconverted into electric energy, and added to the supply going to other motors. The difference in principle is of this nature: the periodic governor corresponds with a man who, when he has not much work to do, does not eat much—lives economically, in fact; whereas our combined motor corresponds with a man who always eats the same amount every day, but when he has little work to do on his own account, immediately goes and helps somebody else who is hard pressed with work. [Experiments were then shown with the combined motor, and it was proved that the change of load which diminished the speed of the ungoverned motor from 1,560 revolutions per minute to 508, only reduced the speed in one of Ayrton and Perry's governed motors of the same size from 1,250 to 1,184 revolutions per minute.]

But we find that it is not even necessary to wind the motor with two distinct circuits in order to obtain a certain amount of governing, and this arises from the fact that our machine will act as a motor without any winding at all on the revolving field-magnets. Here is an example of such an unwound motor. I pass a current through it and it at once commences to revolve, and, as you see, revolves rapidly. [Experiment shown.] This arises from the fact that the magnetism in the stationary armature induces opposite magnetism in the iron of the field-magnets, and the brushes are so placed that the magnetic poles in the armature are always just in front of those in the iron, which latter are always running round and round after those in the former but never catch them up.

In some of the early electro-motors pieces of soft iron moved in the neighborhood of stationary electro-magnets, but in that case the continuous motion of the iron was maintained in a totally different way from that employed in our unwound motors, because in those older motors a piece of iron was pulled towards a stationary electro-magnet, opposite which it would have stopped, but that just as it was approaching the end of the electro-magnet the current was stopped and the iron went on by its own momentum; the pulls were therefore intermittent and not continuous, as in the case of our unwound motor.

Now, suppose we have one of our motors adjusted to run without any winding on the field-magnets, and imagine we wind the field-magnets in such a direction that the motor would tend to turn in the opposite direction when a current passed round the coil wound round the field-magnets, what would happen? Why, if the magnetism induced in the field-magnets by the current flowing round it were stronger than the opposite magnetism induced in the iron by the armature we should have the very curious and novel result that the direction of the motor could be reversed by simply short-circuiting, with a thick piece of wire, the current flowing round the field magnets, and this result we have practically attained, as I will now show you. [Experiment shown.] Allow the current to flow through the armature and field-magnets and the motor runs one way; let it only flow through the armature alone and the motion is instantaneously reversed. Merely pressing down the key, then, reverses the motion. Hitherto the much more complicated arrangement of reversing the electric connections between the armature and field magnet had always been thought necessary to reverse the direction of motion of a motor.

We have in the preceding considered that the magnetism produced by the coil on the field magnets was greater than that produced by the induction of the armature itself, and so determined the direction of motion. But suppose that is not the case, then what will happen? Why, in that case the current passing through the coil on the field magnets will be resisting the motion, and so will be helped on. But that, as we saw before, is exactly the condition necessary for governing. The armature then and the iron of the field magnets act as a motor, while the armature and the coil wound round it act as a dynamo, and if the resistance of the coil, which we make of fine wire, and as a shunt to the armature, is of proper resistance, so that the required speed the motor is run at is the critical speed of the dynamo, the governing of our motor may be fairly perfect with only one circuit on it.

Hitherto we have been dealing with motors especially intended always to run at one speed, whatever amount of work they might be doing. We next come to motors for electric tram-cars, tricycles, etc., designed to run at any desired speed forward or backward.

I have spoken about the set of the brushes relatively to the field magnet, and the set, or "lead" as it is technically called, is of great practical importance, since on the amount of lead depends which way the motor revolves, or whether it revolves at all. Although the fact that the direction of rotation could be reversed by a sufficient change in the lead was well known, the importance of varying the lead in motors for different speeds appears to be little attended to, since it is impossible as a rule in motors, from their construction, to make small changes in the lead. In our motors, on the other hand, the flat brush-holder can be revolved forward or backward by hand through any angle, so that any lead forward or backward can be given to the brushes for each speed, and in our larger motors, of which I have a sample here, the lead can be made anything we like simply by moving a handle, such as a locomotive engine-driver is accustomed to use for acting on the link-motion of his engine. Push the handle shown in Figs. 2, 3, and 4 forwards, and the motor revolves rapidly in one direction; pull it backwards, and it revolves as rapidly in the other direction. Push it not so far forwards, and it does not revolve so fast in the first direction; pull it not so far backwards, and it does not revolve so fast backwards. In fact, by moving the handle forwards or backwards any speed, in either direction is obtainable. The action of our "lead adjuster" is as follows: Attached to the rotating field-magnet is the spindle, S S, which is itself attached to and rotates with the outer collar C C. On pushing the handle forwards or backwards this collar is moved along the spindle, and the effect of this is to cause a pin to move along the groove G G and so cause the inner collar P P, which usually rotates along with C C and the field-magnet, to move a little forward or backwards relatively to C C. Now it is the collar P P which is screwed to the brush-holder, hence we are able, even when the motor is running, to shift the brushes relatively to the field-magnet together with which they are rotating, and consequently with only *one pair* of brushes to give any lead forwards or backwards we desire. In other cases we alter the lead by means of a wheel and screw, and so get very easily a very accurate adjustment. A table of speeds can be engraved showing the position the handle should be in for 500 revolutions a minute or 700 revolutions a minute, &c.

On the last occasion I showed you photographs of all the principal electric railways, and we saw that in some cases the current went by an auxiliary insulated rail, passed through the motor under the train, and came back by the rails. In other cases both the going and return wires were of the nature of stout overhead telegraph wires, and a running connection between the motor on the tramcar and these wires was kept up by two small jockeys, that were pulled along the telegraph wires by wires attached to the tram-car. In a third system, the going and return conductors were simply ordinary rails on which the train runs, the insulation produced by the rails merely resting on wooden sleepers having been found sufficient for a length of one or two miles. As you will see from the photographs that I now project on the screen, this last and simplest plan has been adopted for the Portrush Railway, near the Giant's Causeway, in Ireland. This electric railway, Mr. Trail (the chairman) has been so good as to write to me, "runs on a footpath, or trampath, by the side of the road, which has been widened for the purpose from 24 to 27 feet. The path is 7 feet wide, leaving 20 for the carriage-way. We first tried," he says, "sending the current by one rail, returning by the other rail, after passing across by the car, and for this purpose had laid the rails in asphalt with thick felt underneath, but we found that the leakage, especially in wet weather, was too great to justify us in continuing that kind of insulation for six miles." Now this is exactly the result I predicted in my lectures on electric railways delivered last year, and in order to make the difficulty quite clear to you, I will show you the experiment I then showed to prove this. A portion of the going wire conveying the current working that motor driving the circular saw is, as you observe, wrapped round this bit of wood, and a portion of the return wire round this other piece of wood. As the two pieces of wood are dry, there is very little leakage from the wire on the one to the wire on the other, although the wire wrapped round each is bare. If, however, without allowing these pieces of wood to touch one another, I immerse the ends of them in this vessel of water, I shall produce the same effect as if a shower of rain fell at one end of the electric railway. Now observe what happens: the motor immediately begins to go more slowly. Let me immerse them further, which will correspond with the rain becoming more general over the line, and the motor goes still more slowly, and now the motor stops altogether, so much of the current, in fact, leaking from the going to the return wire through the water that sufficient does not pass through the distant electric motor to keep up its motion.

How then has this difficulty been overcome at the Giant's Causeway. Mr. Traill's letter tells us. He says, "We have therefore placed a third rail of iron on wooden props close into the fence, so that a brush sticking out from the car on a steel bar runs along the top of this third rail, which is about 15 inches from the ground. He goes on to say that this third rail is embedded in tar on the tops of the posts, and that when in addition pieces of the new insulating material, 'insulite,' are introduced between the rail and the wooden posts they expect the insulation will be perfect. He adds: "At present we can run for over two

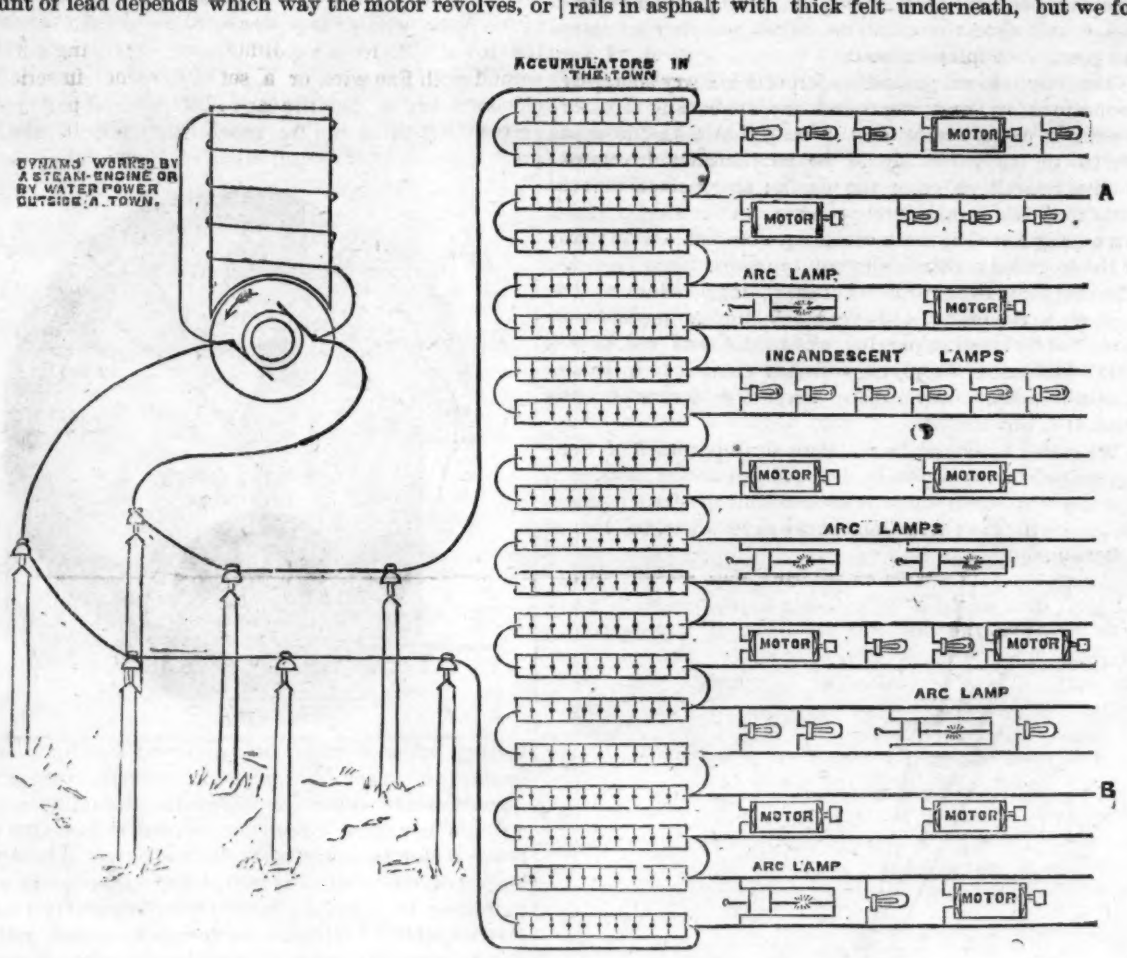

FIG. 5.

* See page 182, OPERATOR AND ELECTRICAL WORLD, March 24, 1883.

miles on the road up and down hill gradients as great as 1 in 35. We took six tons up that incline the other day. We are about to erect turbines at the Waterfall above Bushmills, which will give us from 60 to 100 horse-power, and will generate the current there about half a mile from our main line at Bushmills. We have powers by the Act of Parliament to construct a railway from Bushmills to Dervock, inland about seven miles, almost at right angles to the line of tramway on the sea coast. As the waterfall is near the junction of railway and tramway we intend to use it for the railway as well, as the works will do for both. We are limited by an act to 10 miles an hour on the tramway, but will have no difficulty in going to 20 or 25 miles an hour on the railway, which has also the advantage of being level the entire way."

But although they have succeeded at Portrush in overcoming the difficulty of leakage by using this third insulated rail, resting on posts 15 inches above the ground, such a system presents, you will easily see, great inconveniences for ordinary railways, since at every crossing there would be this raised rail in the way of the trains, and an even greater objection is the risk that it introduces, that any one can, from carelessness or malice, by resting, say, a crowbar against this raised insulated rail, send all the electricity to the earth and so cut off all electric power from all the trains either in front or behind.

On the other hand, the plan of using stout telegraph wires, with running jockeys to keep up continuous electric connection between these wires and the moving trains, would present great mechanical difficulties if the trains were going at 60 miles an hour.

What, then, do we propose? Professor Perry's and my plan is shown in the pictures in your hands, and is this: we electrically subdivide the rubbed rail into a number of sections all fairly but by no means perfectly insulated from the ground. We do not apply our electricity directly to this rubbed rail but, instead, to a well-insulated conductor, which may be buried underground or may be insulated by resting like a telegraph line on insulators on posts, and we arrange that whenever a train enters on to any section, it automatically makes an electric connection between that section of the rubbed rail and the well-insulated conductor which supplies the power, and at the same time automatically cuts off the electric power from the section the train has just left, and in this way we confine the leakage of electricity to that section on which the train is at any particular time, and so reduce the leakage and waste of power on the longest electric railway to less than it is at present on the shortest line constructed on the Berlin plan.

But not only does a train on entering any section automatically turn on the electric power to that section and cut it off from the one just left, but it accomplishes something more: it blocks absolutely the section just left. Let us take an example: Suppose a train is passing from section *A* to section *B*, then not only is the power automatically turned on to section *B* and cut off from section *A*, but no following train entering on section *A* can receive power and move on as long as the train in front is on section *B*. It is not until the preceding train has passed into section *C* that the following train can proceed along section *A*. And, in addition, whenever a train is approaching too near a train in front and in consequence finds itself deprived of driving-power, it is, by a special plan we have contrived, automatically powerfully braked.

Whenever, then, a train—it may be even a runaway engine—enters on a blocked section not only is all motive power withdrawn from it, but it is in addition automatically powerfully braked quite independent of the action of signalman, guard, or engine-driver, even if either the latter two men be present, which, bear in mind, is not at all necessary with our electric railway. No fog, nor color blindness, nor different codes of signals on different lines, nor mistakes arising from the exhausted, nervous condition of overworked signalmen, can with our system produce a collision. The English system of blocking means merely giving an order to stop, but whether this is understood or intelligently carried out is only settled by the happening or non-happening of a subsequent collision. Our absolute automatic block acts as if the steam were automatically shut off and the brake put on whenever the train is running into danger; nay, it does more than this, it acts as if the fires were put out, and all the coal taken away, since it is quite out of the power of the engine-driver, if there be one, to re-start the train until the one in front is at a safe distance ahead.

At present much household work is done by hand, simply because there are no easily worked machines for doing it. The old knife-board has given way to the rotary knife-cleaner, but even that requires a certain amount of grinding to give the knives a polish, so that for large establishments a knife-cleaner boy is still necessary. The blacking of boots, the blacking of grates, the cleaning of doorsteps, etc., are all done in a most laborious way by hand. (I might almost say the operation seems not to be confined to hand, judging from the general smutty appearance of Sarah Anne after the process.) Now, there can be no doubt that very shortly electricity will be supplied, as gas is now supplied, to houses for lighting purposes, and when this has been accomplished the same wires that convey the electricity for lighting can in the day convey the power to work electric motors to turn rotary knife-cleaners, to turn a wheel for the blacking of boots, and a small motor carrying a brush like the one in my hand will simply be passed by the servant all over the grate for the purpose of giving it a good black polish. The black-lead brush will then be taken off, and replaced by the blacking brush for the boots, and later on in the day a rotary flannel will officiate for the door-steps.

The high price of land in towns necessitates gas-works being in the suburbs, so in the future the electric works must be in the country, and probably farther away from the towns than even gas-works are at the present time, because not only will great economy be so attainable, but the town will be freed from the smoke of the engines to drive the dynamo machines or producers of electric current, and by that time we shall have begun to realize that a smoky atmosphere is a poisonous atmosphere; further, if our dynamos are far away in the country advantage can also be taken of natural sources of water-power.

The transmission, then, of power by electricity is not only a problem which must be solved, but is one which calls for immediate solution.

For the economic electric transport of power we must produce, as I have explained, a great difference of potentials by a dynamo at the place where the power is obtainable—in the suburbs where, for example, is the steam-engine or water-wheel—and employ some mechanism which can be worked by this great difference of potentials at the place where the power is to be utilized—that is, in the town. There is no difficulty in arranging a dynamo wound with fine wire, or a set of dynamos in series with one another, to produce any difference of potentials required; but there is a far greater difficulty in using this great difference of potentials at the town end of the line.

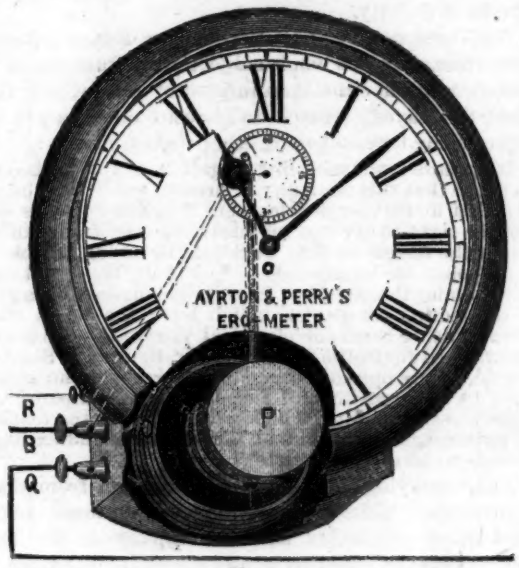

FIG. 6.

If lamps and motors of the present construction are used they would have to be put in series, but in that case if the current is stopped passing through one it will be stopped passing through all. This difficulty can to a great extent be avoided by using "cut-outs," as I described to you in my last lecture. At the same time nobody would be perfectly satisfied that his supply of electric power should depend on the good working of all the electric apparatus in the same street, much less that it should depend on the good working of all the electric apparatus in the same town. We are content that our supply of gas or water should depend on the good working of the gas or water-works, but we could not tolerate the possibility of Betsy Jane, in Moorgate street, from some carelessness or other, being able to cut off our supply at the London Institution. That Jack Frost should stop our supply is bad enough, but Betsy Jane—no!

What, then, are we to do? High difference of potential we must use, and we cannot work the lamps and motors in parallel unless they have a resistance of tens of thousands of ohms, in fact, are of a totally different description from the lamps and motors of the present day. The solution was first suggested by Sir William Thomson in 1881, and, I am happy to say, will very shortly be carried out by Prof. Perry and myself in Paris, under the auspices of the French Electrical Storage Company. It is to use the small current and great difference of potentials to charge a very large number of accumulators, in series, in the town, and to discharge them in sets, as shown in the figure, each set supplying the energy for one street, or, possibly, for one district. Of course, the going and return wires between the dynamo and accumulators must be separately insulated and put so far apart that there is no fear of a man or an animal accidentally touching both. If, in addition, it is feared that although this precaution is taken still somebody may touch a leading wire, say, *a*, coming from somewhere near one end of the accumulators, while another person may accidently touch a leading-wire, *b*, coming from somewhere near the other end of the accumulators and so both receive a fatal shock, this may be also entirely avoided by electrically disconnecting the various sets of accumulators from one another and from the

(*Continued on page* 197.)

Fundamental Principles of Electricity.

BY P. H. VANDER WEYDE, M. D.

IV.

The remarkable fact (brought forcibly to light by the experiments described in the former article) that the two opposite electricities neutralize one another when united, is the foundation of the theory that *all bodies possess naturally these two electricities, which show themselves only when they become separated.*

The different agencies by which this separation may be effected generate various forms of the two electricities, of which the first and most simple is produced by friction. It is this form which we consider first in this series of articles, because it produces the most tangible electricity best adapted for the study of its properties. For this reason, it was the first form to be discovered and experimented upon. By itself it is of comparatively little practical utility, but it has opened the door to the knowledge of other more useful forms which, without the preparatory study of frictional electricity, would forever have remained undiscovered.

That the friction by which we obtain electricity does actually separate the two kinds which neutralize one another in all bodies, is proved by the fact that if the rubbed body becomes positive electric the rubber becomes negative, and *vice versa.*

THIRD SERIES OF EXPERIMENTS.

This separation of the two electricities by friction can be shown by those friction electric machines in which the rubbers are insulated. They show that while the glass becomes positively charged the rubber will be found to have become negative. Without the possession of such a machine, it may be shown by insulating the piece of bronze powdered leather used for rubbing the glass rod; this is easily done in separating it by several thicknesses of silk or very dry wool from the hand which holds it, and taking care to discharge frequently the positive electricity from the glass, so as to prevent the communication of it to the leather. Very soon the latter will possess enough negative electricity to show its nature upon one of the electroscopes described on page 179 of our former number. (Attentive readers will have noticed an error in the numbering of the figures on page 179, Fig. 5 being the gold leaf electroscope, Fig. 6 the straw electrometer and Fig. 4 the electrometer of Coulomb; substituting those numbers, the explanation in the text will refer to the right figure).

Experiments have shown that it is not absolutely true that glass always becomes positive electric, nor vulcanite, or sealing wax, negative. This depends upon the substance with which it is rubbed. When glass is rubbed with cat's fur it becomes negative, and when vulcanite is rubbed with bronze powder it becomes positive. The reason is that cat's fur is the most electro-positive of all substances, while the noble metals are the most electro-negative, consequently cat's fur and also wool will make any substance rubbed with the same negative, while noble metals will make them positive.

As it is not practical to rub glass effectively with a piece of metal, a metallic paste used to be employed, by making an amalgam of mercury, tin and zinc, mixing this with tallow and applying it to the leather rubber of electric machines. As in the course of time this mixture dries out, becomes hard and may scratch the glass, well informed electricians have abandoned its use for the sulphuret of tin.

That the friction of a solid and a liquid may also develop electricity, is proved by a machine made by Van Marum, in which a disc of shellac was, with its lower edge, dipped in a bath of mercury. By the rotation of the disc, the mercury and the disc became charged with opposite electricities.

Cat's fur and negative metals being the two extremes for the development of positive and negative electricities by friction, the question may be asked if a table may not be constructed showing the relative position of bodies in regard to these properties, similar to the table we gave on page 165 for conductors and insulators. We give here such a table, which shows how, when two bodies are rubbed together, the preceding one will be positive and the following negative electric.

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We will abstain from giving more details about peculiarities discovered by various investigators. The above is sufficient to show that a great deal of labor has been spent in this field, which was comparatively neglected during the last fifty years, by reason of the startling discoveries in voltaic electricity and electro-magnetism which absorbed the universal attention. For the last few years, however, a reaction has taken place, and several electricians have by approved appliances contributed largely, as well to our knowledge of the nature and application of this kind of electricity, as to the methods of producing it. These will be described in proper order.

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SOME TELEPHONE YARNS.

A reporter of the Cleveland *Leader* writes to that journal from Washington that he has had a conversation with a gentleman who is largely interested in the manufacture of the Bell telephone and of telegraphic instruments, but who is "so well known to the electricians of the United States and to the parties interested that he does not wish to have his name given." The statements made by this gentleman to the reporter, the latter naively says, caused him much surprise. Some of them would have that effect upon almost any one; for instance, his statement as to the greatest electrician in the United States. Most people have an idea that if any one is entitled to claim that distinction it is Mr. Edison, with Messrs. Bell, Brush and Weston not far behind, but according to this gentleman, America's only greatest electrician is Mr. George W. Coy. Mr Coy, he says, "lives at New Haven, and owns a magnificent residence at Millford, near there. He has more electrical patents registered at Washington than any other man in the United States. He has now sold all his patents to the United States Telephone Company and has nothing to do with Bell's. The Bell men fear him, and awake every morning expecting to hear that he has perfected some new invention which will throw them entirely out of the market. Coy gets five thousand dollars a year for doing nothing. He takes a trip to New York every now and then, and the United States Company ask his advice as to electrical matters, and they pay him this money for what he tells them. He is by all odds the brightest electrician in the United States."

No wonder the *Leader* man was surprised. But this was not all. The telephone man then went on to show how the telephone business of the country is about to be swallowed by the insatiable Jay Gould, the only hope of the country now being that Mr. Coy may awaken to the gravity of the situation and do something. "A big scheme," he says, "is now on foot to monopolize the whole telephone business. It is engineered by the Bell Telephone Company, the Western Union Telegraph Company and Jay Gould. These people propose to control the telephone interests of the United States, and to combine them into such an organization as the Western Union. The telephone is going to supersede the telegraph in this country, and Jay Gould is keen enough to see it. Why, just the other day I held a talk with a man over seventy-five miles of wire, and the sounds came as clear as a bell, thoroughly intelligible. You can talk further than you can telegraph, and a slight change in the invention might enable a child in New York to hear the voice of his mother in San Francisco. The time will come, within a very few years, when the different cities and villages of the United States will be connected by telephone. They are so to a great extent at present. Jay Gould & Company propose to monopolize all this vast business of the future. They are now buying up all the little exchanges, and they own a controlling interest in nearly every State in the Union. They have some stock in nearly every company and they own Boston, Baltimore, Pittsburg and New York. The Bell Company, you know, until lately has been merely renting its instruments, making the company pay so much a year for each bell used. They now sell the bells outright, in consideration that the exchange to which this privilege is granted will water its stock 33⅓ per cent. and give that stock to them. Suppose an exchange is stocked at $100,000; they increase their capital stock by water to $150,000 and hand over this last $50,000 to the Bell Telephone Company for this privilege. When these men in this way have obtained a monopoly of the whole thing, they will buy out the smaller fry, combine the whole, and make it the biggest paying investment in the United States. The stock will then go on the market at fancy figures, and the boom in Gould's Bell Telephone will far surpass that of Western Union when his name was lately used in connection with it. There are, however," continued the telephone man, "several contingencies which may arise. The United States Telephone Company is fighting the monopoly, and should Coy make some wonderful discovery, it might certainly turn this golden cake into good-for-nothing dough. A third party also claims that Bell has no right to his patent, and he intends to fight the matter out in the courts. He claims he has a patent, identical with that of Bell, issued to him fourteen years ago. If this is so, the Bell Company must take a back seat, or by some means obtain his patent, in which case they would be vitally opposed by the United States Telephone Company."

WE noted last issue that a delegation had waited upon Mayor Edson, of this city, asking him to approve the resolution passed by the Board of Aldermen, March 13, permitting the New York Electric Lines Company to lay wires or other conductors of electricity in and through the streets of the city.

On Tuesday last, however, Mayor Edson vetoed the resolution. As this whole subject of the running of wires underground in cities is an important one at the present time, the Mayor's remarks in his veto message are worth reproducing here. Among other things, he says:

It appears from such investigation as I have been able to make that this company at present exists only on paper, and that its further development depends upon its obtaining the right to lay and maintain lines or trains of wires under the streets of New York and Brooklyn, which wires it proposes to lease. * * * The right to lay wires under the streets of this city has already been granted to three other companies, which have the wires and are already using them for electrical purposes. To grant the right asked for in the petition of Mr. Sydney F. Shelbourne would, in my opinion, be again to surrender the streets of the city for experimental purposes to a company of unknown responsibility, which would involve the tearing up of pavements in any and all of the streets and excavations therein to an unknown extent.

Accompanying the veto was an opinion from Corporation Counsel Andrews to the effect that there might be some question whether such a company as the Electric Lines Company could be legally incorporated under existing laws. Under the rules, the Mayor's veto was laid over for future action. It was generally believed in the Aldermanic chamber that the company could secure enough votes to override the veto; though the daily papers, who are bitterly opposed to the company, say that if this be done other means may be found for keeping Mr. Shelbourne and his "Electric Lines Company" out of the streets.

THE statesmen in Pennsylvania who are endeavoring to punish the Western Union and Mutual Union Companies for consolidating, by passing a law escheating to the Commonwealth the property of the latter company, had better drop the subject and close the stable-door before the next horse shall escape. The Federal Constitution forbids the passage of an *ex post facto* law, but some ingenious Pennsylvanians meet this obstacle with the argument that this Constitutional prohibition applies only to laws relating to *crimes*. The Federal Courts have frequently passed upon the subject, and we are indebted to the *Press*, of Philadelphia, for searching out the two following clear decisions: "In the case of Falconer *vs.* Campbell (2 McL. 196) it is decided that the Legislature cannot create an obligation or impose a penalty for an act which, when done, incurred no such liability. In the case of Cummings *vs.* Missouri (4 Wall. 277) the Supreme Court held that the State could not inflict punishment for a past act which was not punishable at the time it was committed." Even were there no constitutional mandate upon the subject, it would be absurd to claim in this country that a telegraph company's rights could be forfeited for an act for which, when committed, there was no penalty. The Mutual Union consolidation is complete, and the energy lost in a wild-goose chase after its devourer would be better spent in encouraging another opposition line to take the field, and in keeping it there when it shall be developed.

In the United States Circuit Court at Trenton an important decision has been rendered in the case of the Bell Telephone Company against Andrew Albright and John J. Ghegan, of Newark. Ghegan attempted to introduce a telephone manufactured by the People's Telephone and Telegraph Company, and a line was run from the office of the company to the store and residence of Andrew Albright in Newark. A suit was brought against them by the Bell Telephone Company for infringement, and the case was tried some time ago. The validity of the Bell patents was assailed and a very strong contest resulted. On Wednesday last, March 28, Judge Nixon made an order which sets forth that the two patents granted to Alexander Graham Bell on March 7, 1876, and Jan. 30, 1877, are good and valid patents, and that the defendants, combining and confederating with the People's Telephone and Telegraph Company, have infringed the same; that it be referred to S. D. Oliphant to ascertain the damages sustained by the Bell Company as well as the profits and gains of the defendants for the use of the infringing instrument. Further, that a perpetual injunction be issued restraining the defendants and all others from further infringing the said letters patent. It is stated that the case will be carried to the United States Supreme Court, but this is not very probable.

THE annual meeting of the stockholders of the American Bell Telephone Company was held in Boston on the 27th inst. The following officers were elected: Directors, Francis Blake, Charles P. Bowditch, Charles S. Bradley, George S. Bradley, Channing Clapp, Alexander Cochrane, William S. Forbes, Charles Eustis Hubbard, Gardiner G. Hubbard, Robert B. Minturn, William G. Saltonstall and Thomas Sanders; treasurer, William R. Driver; clerk, Charles E. Hubbard.

The report of the treasurer to March 23 showed the total earnings for the past year to be $1,576,031, those of the previous year having been $1,001,924; expenses for the past year, $603,987; for the year previous, $439,862. Twenty-seven thousand two hundred and ten subscribers have been added during the past year, and 2,020,284 miles of wire have been added. The underground wires in Boston have been found to transmit distinctly only for short distances, and it will be necessary to devise a further improvement before they can be made available to any extent. It was voted that the capital stock of the company be increased from $7,300,000 to $9,800,000, and that new shares be allowed on the basis of one share to each holder of the old ones. Owing to the increasing number of shareholders, the directors were authorized to hold their annual meetings at such places as they may designate.

THE new "Western Union Company of Illinois," which has begun *quo warranto* proceedings against the old original Western Union, charges the latter with a great many misdemeanors and, among them, an ignoble attempt to cheat the Tax Collector. The eighth section of the petition filed in court says: They (the old Western Union) have abstained from being incorporated in Illinois for the purpose of avoiding taxation. For this purpose they once filed a bill in the United States Circuit Court, in 1874, for the Northern District of Illinois, in which they said: "Your orator shows this is a foreign corporation, and has no intangible property in the form of franchises, or other intangible assets in the State." In another bill, filed against the collector of Cook County, they said: "We fail to find any statute under the provisions of which it can be said the Western Union Telegraph Company is even constructively incorporated under the laws of the State. We are, therefore, compelled to assume that it is in theory as well as in fact a foreign corporation, exercising its privileges and franchises in this State by comity only." By each of these bills it evaded an assessment of its stock and franchises at $1,168,394.

IT is decidedly rough on the Western Union Telegraph Company (Gould's) to have the Western Union Telegraph Company (of Illinois) steal its good name and then ask the courts to crowd the old original out of Illinois altogether, by bringing *quo warranto* proceedings to make it show by what right it does business in that State. But, it is harder still to find that in an effort to evade the tax-gatherer, nine years ago, the original Western Union then demonstrated in the United States District Court for the Northern District of Illinois that it was not "even constructively incorporated under the laws of the State," and that it was "in theory as well as in fact a foreign corporation." The parvenu concern is making good use of this old argument. There's a good deal of "meat" in it for the lawyers and speculators, and as long as the Western Union is prepared to buy up its troublesome rivals and persecutors, we should not wonder at the state of affairs which led Col. Clowry to remark smilingly that "it seemed as if there were a number of people who had nothing else to do except to bring suits against the Western Union"—poor thing!

"SEVERAL of our friends in this city have had their sense of hearing diminished in one ear by constant use of the telephone. Persons who use this instrument are apt to apply it to the same ear every time, and the consequence is the organ is overworked, and slowly approaching deafness in that ear is sure to follow. Several parties in this city who are affected by it have applied to an eminent aurist in Boston, who reports the cause as above described. He recommends that persons who use the telephone apply the instrument alternately to their right and left ears."

We clip this item from the Fall River *News*. There seems to be sensible advice in the latter sentence. There is no doubt that the ear can as readily be overworked as the eye. There is no acoustic apparatus which gives such indistinct sounds as is often the case with the telephone. We consider it better to use two telephones at the same time—one for each ear—which will tend to equalize and lessen the strain, the ears assisting one another.

A GLANCE at our "Telephone Department" to-day will show that there has lately been quite a boom in telephonic inventions, though we are not quite sure that the phenomenal success of the newly-invented batch of transmitters and receivers is not due more to the remarkable qualities of the new wires used by the Postal Company than to the intrinsic merits of the instruments. It is now claimed that New York has said "Hello" to Chicago, and that the "Hello, New York," has come thrilling back over the 1,000 miles of line as clear as a bell. Be this as it may, it is a fact that the best electricians of the country are now hard at work on the problem of long-distance telephoning, and it is likely that their researches will soon result in the complete annihilation of induction and retardation, to say nothing of hundreds of miles of space. The sentry on Governor's Island may yet signalize sunset on this meridian by firing "the shot heard round the world."

THE name of the *Review of the Telegraph and Telephone* has been changed to *The Electrical Review*. Commenced on the model of THE OPERATOR, as far as appearances were concerned, it has promptly recognized the typographical beauty and increased size of THE ELECTRICAL WORLD by increasing its own size to correspond, and becoming *The Electrical Review*. We hope, for the welfare of its readers, that it may be equally as successful in imitating the value and volume of electrical news presented in our columns.

IT is eminently proper that Cornell University—established by one of the earliest and most indefatigable workers in the field of telegraphy—should inaugurate a course in electrical engineering. The electrical world is constantly widening and deepening, and the abstruse principles of electrical science cannot be better taught anywhere than at Cornell.

THE declaration of the Bell Telephone managers that a subterranean system of underground wires is at present unsuited to their system receives timely corroboration in a report by Lieut. Greene, recently published. Whatever may be said of the underground system for telegraphs and electric light wires, it cannot yet be adapted to the telephone for general use.

ADVOCATES of a postal telegraph monopoly in this country can reflect upon the report of the British Post-Office for the year ended March 31, 1882, from which it appears that there was a deficiency of telegraph revenue in the year to meet interest on telegraph stock created of over half a million dollars.

THE surprising progress made by and wide free advertising given to the Postal Telegraph Company seems to be giving serious alarm to the more timid holders of Western Union stock. The latter company's litigation seems interminable and must be distracting to the managers. There is a world of hard work in store for them.

THE death of Mr. Charles G. De Moll, at Philadelphia, will recall the strike of the Franklin operators in 1869—the only successful telegraphers' strike on record. He was the moving spirit in that affair, and the qualities then displayed in bringing the strike to a successful issue served him well subsequently in other walks of life.

THOUGH a remedy has not yet been found, there is some basis for the public alarm about overhead wires in the report of the Bell Telephone Company, which shows that during the past year two million miles of wire have been added to its system.

AN electric motor for street cars, such as is claimed to have been perfected by Mr. Leo Daft, which shall be simple in construction, completely under control, and cheap, besides occupying little space, should soon effect a complete revolution in street traffic.

AN increase of 27,210 subscribers during the past year, as was reported in Boston last Tuesday, shows a growing interest in the telephone on the part of the general public.

Electric Lighting and Locomotion.

(*Continued from page* 195.)

main charging wires coming from the dynamo before they are connected respectively to the local leads in the streets for being discharged.

Suppose a thousand accumulators were thus employed, and a charging current of 33 ampères were used. To balance the electro-motive force of the accumulators about 2,100 volts would be required. If the resistance of each cell were 0.005 of an ohm during charging, then 165 volts difference of potentials would be required to send a current of 33 ampères through this resistance, or a total difference of potentials of 2,265 volts would have to be maintained at the terminals of the accumulators. Hence about 100 horse-power would be put into them.

The next question that arises is, What size of conducting wire is it proper to use to convey a current of 33 ampères? If the conductor is thin it will certainly not cost much to erect, but, on the other hand, the resistance to the passage of the current will be great, and much of the power will be wasted in the heating of the wire. On the contrary, if the conductor is very thick, there will be practically no waste of power by the heating of the wire, but the capital sunk in working it will be excessive. It is clear, then, that there is some thickness which gives us the best results, and Sir William Thomson has worked out this problem for us, and has shown us that the thickness of the conductor proper to be used for any particular current does not depend at all on the length of the conductor, but depends first on the strength of current passing through the conductor, second, on the cost of copper per ton, and, third, on the market value of one horse-power supplied for a year. Assuming that good conductivity of copper costs £70 per ton, and that the market value of a horse-power is £10 per annum, the proper diameter to give to a conductor conveying a current of 33 ampères comes out to be 32-100 of an inch, or a trifle over 3-10, on the assumption that the current passes for 12 hours out of every 24.

In order to send this 33 ampères through ten miles of going and ten miles of return copper wire, 32-100 of an inch in diameter, as well as through the 1,000 accumulators, will necessitate the dynamo producing a difference of potentials of 2,654 volts. Under these circumstances, calculation shows that about 17 horse-power would be lost in heating the line-wires, about seven horse-power in charging the accumulators, and about a further 25 horse-power in the dynamo itself, which is in the country. 142 horse-power must, therefore, be given by the steam engine or water-wheel to this dynamo.

We come to the conclusion, then, that if 142 horse-power is given by the engine to the dynamo, 117 is given up by the dynamo to the wires; 100 is given up by the wires to the accumulators in the town, and 93 is stored up in the accumulators for future use, the total horse-power usefully stored up in the accumulators being in this particular case about 65 per cent. of that given to the dynamo by the engine.

The world thinks of a current of electricity as it thinks of a current of water. Now, there is this very essential difference between the supply of electricity to houses and the supply of gas or water to houses. When gas is supplied, you have only to deal with the *quantity* supplied; you are not going to use the pressure of the gas to do work, even if the gas is to be used in a gas engine. It is only the burning of the gas that you are interested in. You are really dealing, therefore, with *quantity* of gas. Similarly when water is supplied, nobody cares very much about the pressure so long as it is sufficiently high to reach the top story of his house. But if the pressure is 700 lbs. per square inch, as used by Sir William Armstrong, or 1,500 lbs. per square inch, as used by Mr. Tweddell, then the pressure becomes a very serious matter. Ordinary water is mainly used for drinking and washing purposes, and although this high pressure of water could also be used for drinking and washing, nobody but a millionaire would think of such extravagance; for it is not merely water but water at a pressure of 1,500 lbs. per square inch that is supplied, and every cubic foot of water received per minute at that pressure by the consumer means 6 horse-power. In that case the pressure is all-important, and for measurement you must take the quantity of water multiplied by the pressure. And although mere quantity of water may be important for washing purposes, we know of no purpose requiring mere quantity of electricity; it is needed as a source of energy to drive a motor, or to produce light, and the *amount of energy*, not the *quantity of electricity*, is what must be measured.

In any proper commercial recording meter for electricity a record must be kept, therefore, of two things, the quantity of electricity and the pressure which it is supplied at. Now, the electric meter or "ergmeter," as we call it, designed by Prof. Perry and myself for this purpose, is hanging up here (Fig. 6). It consists of a fairly good pendulum clock, possessing a seconds hand. The pendulum bob has been taken off and a coil of wire p of about 1,000 ohms resistance substituted in place of it. Fixed on the case of the clock, near the fine wire coil, there is a coil of thick wire c through which the main current passes. The course of the current is this: It enters the house at the binding screw b passes through the coil of thick wire c, comes out at the binding-screw q and proceeds through all the electric lamps, motors, or other electric machinery in the house, and then passes away either to the electric main under the street or to another house. The binding-screw B is, as the figure shows, not only connected to one end of the thick wire coil, but is connected to one end of the fine wire coil of the pendulum which passes up the pendulum-rod. The other end of the fine wire coil which passes up the other side of the pendulum-rod is connected to the binding-screw r and r is connected by means of a fine wire to the electric house-main just where it leaves the house.

The current passing through the pendulum bob depends on the difference of electric pressure at the main where it enters the house and leaves the house, whereas the current passing through the thick wire coil c, is the total current working the lamps and motors. Now, the electric power being supplied to the house depends on the strength of one of these currents multiplied by the strength of the other, and it can be proved mathematically as well as, of course, experimentally that the total quantity of electric energy supplied to the house during any time, whether sometimes in the form of high pressure and small current or sometimes in the form of small pressure and large current, is exactly proportional to the loss of the clock in that time. The number of minutes of slowness is the measure of electric energy supplied to the house, and is what should be charged for. An ordinary clock may doubtless lose a few minutes in a week, but we of course make the loss which we want to observe much greater than this. An ordinary clock wants winding up every week, but this of course is easily got over, and if experience in the future shows that the observations of the ergmeter by the electric inspector are only taken at such distant periods that the clock would lose more than twelve hours between his visits, due to its measuring the electric energy supplied to the house in that time, then a hand will be added which takes, if we like, a day to make one complete revolution.

In the legislation which has recently taken place in connection with the commercial supply of electricity, a mistaken notion has grown up that the *quantity* of electricity is what should be recorded, and not electric energy. Now, not only is this bad in that it prevents an estimate being easily formed of the relative prices charged by the different companies for the supply of electricity, since the different companies use normally very different electric pressure, but even the most perfect system of governing dynamos, such as I described to you last time, or of laying the wires under the streets, such as has been suggested by Mr Edison, will not enable the electric pressure at any house to be kept absolutely constant during the evening, even if the electric pressure at the mains where they leave the dynamo is kept absolutely constant.

That is to say: With any system that has been hitherto suggested it is physically impossible, and therefore, I need hardly say, cannot be made possible by legislation, to keep the pressure at a considerable distance from the producing station absolutely independent of the number of intermediate houses that are consuming electric power. In our opinion, then, we should not tolerate either the recording of or the paying for the *quantity* of electricity supplied, but we must record and pay simply for the total electric *energy* supplied.

Two years ago the storage of electric energy in black boxes, and their power taken out of them by Sir William Thomson, may have passed before the minds of the public as one of those mere seven days' wonders which in these latter times have become so common. But to the scientific man, who could foresee the possibilities connected with the electrical storage of power, these experiments of Sir William Thomson were of pre-eminent importance.

The latest two employments of electricity stored in Faure-Sellon-Volckmar accumulators are in the boat *Electricity*—which many may have seen running last Saturday at Kew and a photograph of which I now project on the screen—and the electric tricycle of Prof. Perry and myself. In the tricycle no work is done by the rider, but little black boxes, carried on the base-board, contain the stored electric energy, pretty much in the same way as a horse's body contains its breakfast of oats and hay, with the difference that with the accumulator it is the receptacle which has weight, so that neither in receiving its feed in the morning nor discharging its power during the day does the accumulator gain or lose in its weight. By means of a tap the rider can turn on more or less electricity and go faster or slower. The faster he is going the less is the waste of the electricity, although, of course, the consumption of power is greater than when going slowly—that is to say, the faster the tricycle goes, the more efficient is the whole arrangement. On the other hand, when the electric supply tap is turned off, and the tricycle is at rest, the waste in the accumulators is not large, and the tricycle stands for days ready for immediate use without any waste analogous with an unused horse "eating his head off."

But although the electric tricycle ceases using up its last supply of electricity when it stops, and requires no feeding while motionless, still it must be fed periodically if used regularly. But very shortly I expect to see the tricyclist dismounting at his inn, with the sign, perhaps, of the "Faraday," having the certainty that in the morning he will find his accumulators fully charged up with the electric machine of the inn, also used for lighting and agricultural purposes. I feel also sure that when this is the case the charge in his bill for the electric feed will be one of the smallest items entered.

Let us now adjourn to the Library to see our electrically lighted and driven tricycle in actual operation, and which the size of this lecture hall, large though it be, prevents my showing you here; and, that you may judge of the tricycle's power, I may mention that with it we have actually run a measured mile in 8¾ minutes when the tricycle was carrying a man of average weight and the necessary supply of electric accumulators to propel it for about two hours.

What stored electricity can do, the accumulators before you—lent me by the kindness of the Electrical Power Storage Company—have shown. What the future of electric locomotion can be, who can say? the subject is yet young—very young. Improvements on what I have told you about to-night will doubtless be made; perhaps Professor Perry and myself already see how progress may be made; but, at all events, I trust I have shown you that electric locomotion is already so far developed as to be a real commercial subject of discussion.

New Telephone Transmitters.

Mr. J. Munro read an interesting paper on the above subject before the Society of Telegraph Engineers and of Electricians, in London, on Thursday evening, March 8th. His remarks and experiments, as well as the experiments of Mr. Stroh, which followed, will well repay careful perusal by American telephonists and electricians.

Mr. Munro commenced by saying that he was a witness in the case of the United Telephone Company vs. Harrison Cox-Walker, last summer, and that the testimony given at that trial suggested to him the idea of getting out a new telephone transmitter. He recognized that to make it a novel instrument and one that would not clash with the Edison and other patents, the new transmitter would have to fulfil certain conditions; his connection with the trial showed him what these conditions were.

The broad claim of the Edison 1877 patent is for the combination of a tympan, or drum, with a "tension," or, as Mr. Munro said he would rather call it, a "current" regulator of semi-conducting material. The particular material used by Edison was lampblack, a form of carbon; but the claim has been held in courts of law to embrace all kinds of carbon, and might even be extended to all so-called "semi-conductors."

Since the memorable discovery of the microphone by Professor D. E. Hughes, a great many patents have been taken out in England and abroad for carbon transmitters of one form or another; but the supremacy of the Edison patent, Mr. Munro said, has in general paralyzed these efforts, and rendered the improvement worthless. It is even doubtful if the substitution of protosulphide of copper for carbon by Mr. Moseley in a recent transmitter will be clear of the Edison claim, since that salt is a semi-conductor.

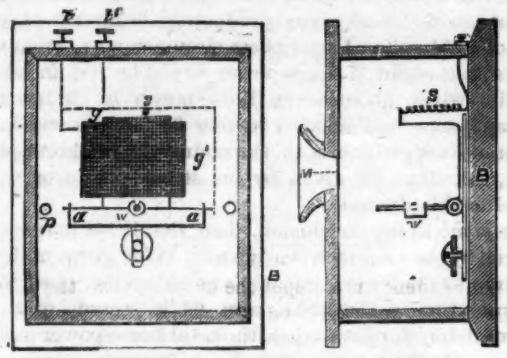
Mr. Munro, therefore, determined to keep clear of semi-conductors altogether, and also if possible, of tympans. He exhibited his transmitters, which are made of metal—that is to say, the current regulator is formed of conductors so arranged as to render a tympan unnecessary.

Some experiments he had occasion to make in the course of the telephone trial showed him; he said the promise which lay in metals as a material for transmitters—a promise first discovered by Professor Hughes in his microphone researches, but neglected by electricians because of the apparent advantages of carbon. Mr. Munro added that he did not believe that the action of the microphone was due to diminution of resistance at the points of contact, by pressure causing greater or less area of surface contact, according to the current theory at that time. It seemed to him, he said, that the film of air between the contact points played an important part in its action, and that the electrodes of a microphone might be of any conducting substance—for example, metals—without destroying its peculiar power of transmitting sounds. He thought, in short, that the current passing through the air between the loose contacts made the sensitive part of the microphone, and that sound-waves traversing this film of air would transmit themselves whether the electrodes were conducting or semi-conducting, carbon or metal.

What kind of metal to use and what particular form to give it in order to get good articulation and durability of action were questions which only experiment could answer. Mr. Munro then explained in detail the experiments he had made in this direction. Continuing, he said that the use of wires in these experiments led to the idea of employing two light wire gratings resting on each other under slight pressure and forming a metal microphone with multiple points. It seemed that the light open structure would allow the sound-waves to agitate the contacts without the intervention of a tympan, and something after the manner of an Æolian harp.

Fig. 1 is a transmitter made on this plan. It consists externally of a wooden box B having a mouthpiece, M closed by a piece of match-wood. Inside the box is the microphone, or "current-regulator," which consists of a piece of ordinary iron-wire gauze *g*, lightly pressed against another piece, *g'*. The back piece of gauze *g'* is fixed to the back of the case, but the front piece *g* is carried by a loose axle *a a*, supported in bearings at each end. From the axle projects an arm, carrying a movable counter-weight, W, and the downward pull of this weight, tending to lift the front gauze off the back, is balanced by the force of an adjustable spring, S. The pressure on the microphonic contacts is regulated by this means. The stops *p p* serve to limit the sidelong play of the axle carrying the movable gauze when it is found convenient to shift the position of the latter in adjusting the instrument. The current enters and leaves the regulator by the terminals, *t t'*. A small induction coil (not shown) is usually inserted between the transmitter and the line, the "primary" of the coil being in circuit with the battery and the regulator, while the "secondary" is in circuit with the line-wire and receiving telephone. On speaking into the mouthpiece in the usual manner the air-waves set up by the voice pass through the two gauzes and agitate the contacts between them, thereby modifying the current so as to make the telephone repeat the words. The match-board diaphragm is not an essential, as the sound-waves act directly on the contacts, but it is useful in screening the regulator from the rudeness o the breath, and fixing the distance at which the speaker should keep. A grating across the mouthpiece answers almost as well. The pole of a permanent magnet presented to the gauzes will hold them together with a force depending on the nearness of the pole. When an electro-magnet E is used, as in fig. 2, the current itself may traverse the coil of the magnet, and hold the gauze *g* against *g'* with a force which will be stronger when the current is stronger, and thus enhance the pressure of the sound-waves, so as to give a more decisive action. It was found that the gauze may be either clean or tarnished, provided the rust upon it is not so thick as to make the surfaces adhere to each other. Two pieces of gauze are not essential to the transmission of sounds, as one piece resting on a flat metal plate, either plain or corrugated, will answer; so also will two thin metal plates with roughened surfaces. But gauze is the most convenient and successful material.

Another type of metal transmitters is shown in Figs. 3, 4 and 5. There B is the case, as before, with a match-board



Front view. Side view.

FIG. 1.—THE GAUZE TRANSMITTER.

screen M and behind it a flat sounding-board carrying a metal microphone *i*, with its adjusting spring S. An induction coil D, having its "primary" in circuit with the microphone and battery and its secondary in circuit with the line, is also contained in the case. The microphone is formed of a light metal bar *i''* resting by its ends in holes drilled in two metal blocks *i i'*, Figs. 4 and 5. An adjusting screw *s* regulates the pressure between the bar and its bearings. The metal found most suitable is common cast-iron which may either be clean or slightly tarnished.

A third type of transmitter is shown in Fig. 6. In this the current regulator consists of metal granules *m* enclosed in a box between two metal plate electrodes *e e'* connected to the terminals *t t'*. The back of the box may either be of wood and the front of wire gauze or both may be of sonorous wood. Iron or brass filings and turnings serve as metal grains, especially those with a good deal of inherent resilience or spring, but a pile of small ¼-inch screw nails or a grit of "spongy iron" gives better results. Spongy iron, having a rough surface, approximates to carbon in its action.

A fourth type of transmitter is that shown in Fig. 7, where B is a box, as before, with a mouthpiece M and an induction coil D. The mouthpiece in this case is closed by a tympan connected at its centre to a metal chain or strip of chain mail *c c'*, which is strained by the springs *s s'* and the tie *f*. This chain is the current regulator and is traversed by the current. Between every two links there is a microphonic joint. The vibration of the tympan, on speaking in front of it, tightens or slackens the chain, thereby operating the current regulator and transmitting the sounds. The pressure between the links, which by preference are of iron, is regulated by adjusting screws.

Mr. Munro also read a "Supplementary Note on the Action of the Microphone." Mr. Edison's original theory, he

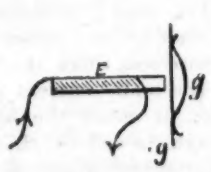


FIG. 2.

FIG. 6.

said, was that the internal resistance of carbon was reduced by pressure. Sir William Thomson supported the theory that the action is due to an increase or diminution in the area of surface-contact produced by increase or diminution of pressure. Mr. Preece considers that the microphone acts by heating at the points of contact when the current passes. It does not seem probable, however, that the variations of temperature can be so quick and sudden as the transmission of sonorous currents requires. Another reading of the theory may be that the heated points are of a spongy nature and more sensitive to pressure, but here again it is difficult to see how the effect can be in simple ratio to the pressure. A fourth theory, supported by Professor Hughes and Professor Blyth and probably first intimated by Mr. F. H. Varley, attributes the action of the microphone to a small arc formed between the points, and this appears to be a likelier hypothesis. Mr. Munro, however, proposes a modification of it, and, instead of an "arc," in the ordinary sense, considers the cause a "silent" discharge through the film or stratum of air or liquid between the points, after the manner of a lightning guard—a silent discharge going on between numerous tiny projections on the carbon points, which in this respect resemble the corrugations or spines in two well-known forms of plate-lightning arrestors used in telegraphy. We have to figure to ourselves the microphone points covered with the irregular projections which touch each other, but are bathed in the surrounding air and ether. These projections, like the points of a lightning arrestor, are constantly discharging little jets of current from one to the other across the air between. But the action of the sound-waves is to move them to and from each other, thereby increasing and lessening the width of the air stratum, and varying the strength of the discharge.

The "boiling" or "buzzing" of a metal transmitter not properly adjusted reveals this "silent" discharge from a multitude of points. If the sonorous waves are too violent the points are separated too far, the contact is broken, and a sharp click is heard in the telephone. This is due to the stoppage of the discharge. It is the sound heard on a larger scale on stopping the current in an arc lamp. It seems an effect of the rarefied arc rather than the heated points, for if it were due to the shrinking of the points it would be observable in an incandescent wire on stopping the current through it. Mr. Munro's opinion is that the rarefaction of the air and ether, caused by the discharge, is the true source of this effect. When the current suddenly ceases, the rarefied gas collapses, and equilibrium of fluid-pressure is restored. The application of heat, by the spirit flame, to two pieces of wire gauze in contact increases the microphonic action between them. When the flame is applied to the metal so as to heat the contact, tapping, as heard in the telephone, becomes louder and gradually dies off when the flame is removed. Hot metals and flame are known to discharge electricity better than cold metals, and hence, in all probability, the slow discharge of the microphone is accelerated by this means.

The recent experiments of Mr. Shelford Bidwell appear to bear out the theory that the microphone acts mainly through the air discharge between the points. Thus, he finds that the resistance of the contacts varies greatly with

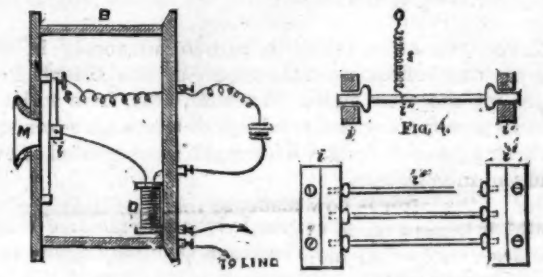


FIG. 3. FIG. 5.

THE BAR TRANSMITTER.

the strength of current when the pressure is small and very slightly when it is great—that is to say, when the film of air is squeezed out. On reducing the pressure (with carbon, at least) the resistance of the contact increases. Again, the resistance of the contact diminishes with increased current, an effect also noticed in the voltaic arc. Further, Mr. Bidwell finds that "when the strength of current exceeds a certain limit the resistance is greatly and permanently increased. The greater the pressure the higher will be such limit." This unexpected effect is difficult to explain on any theory but that of the "air discharge."

A discussion followed the reading of the papers.

Professor Hughes said that he did not agree with Mr. Munro's theory of the air acting as a conductor, since very large currents pass through the microphonic contacts, showing that the resistance is much less than that of air.

Mr. Preece considered the whole action of microphones to be due to heat. This theory, he said, is borne out by the fact that microphones are reversible—*i. e.*, they can act as receivers. The fact that the best microphonic effects are produced with a low electro-motive force is against the air-discharge theory.

Professor Ayrton considered that the microphonic effect was due to a change of electro-motive force, and not of resistance, at the points of contact.

Mr. Stroh referred to an experiment which he had made to determine whether any movement took place in a microphone when a current was passed through it. In this experiment, which may help to throw light upon the action of the microphone, the movements of the carbon piece were magnified by a ray of light in disc reflected from a

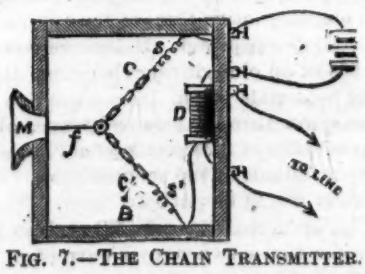


FIG. 7.—THE CHAIN TRANSMITTER.

mirror attached to the carbon. No movement could be perceived when undulations were sent from a carbon transmitter, but makes-and-breaks of contact were distinctly seen.

Fig. 8 represents a very small and delicate form of Professor Hughes' so-called hammer and anvil microphone.

On a thin board A is fixed a little block B which serves to hold four brass uprights, C C' and D D'.

A light spindle E, provided with a pivot or knife edge at each end, rests on the uprights C and C'. Attached to the spindle E on one side is an exceedingly light concave reflector F, while on the other side, and in good electrical contact with this spindle, is a thin rod of carbon G. The latter rests at right angles on another rod of carbon H, which is firmly fixed in the two brass uprights D and D''.

Terminals I and I' communicate each with a pair of the brass uprights. A little spiral spring, the tension of which can be regulated by a small thumbscrew, serves to keep the two carbons in microphonic contact.

A loud ticking watch or other source of sound is placed on the board A.

The general arrangement of the experiment is shown in

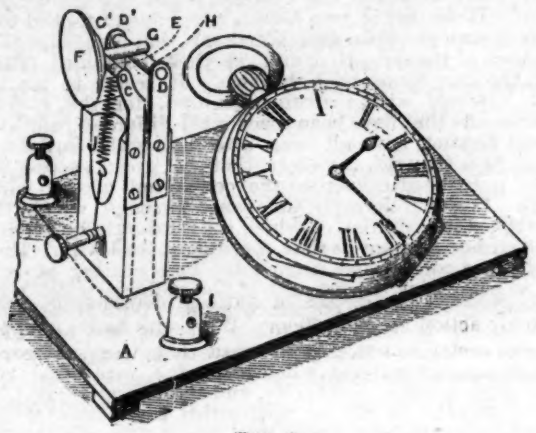


FIG. 8.

Fig. 9. M is the microphone just described. A lime-light L is placed behind a little screen with a small round hole in it, across which is stretched a fine wire, so that the image of the latter is thrown by the reflector of the microphone on a wall or screen at S, where a graduated scale may be fixed, and where by means of the image of the fine wire any deflection may be easily read.

A downward movement of the reflected spot of light on the screen S indicates a separation of the carbons at the point of contact, while an upward movement would be due to an approach of the carbons towards each other.

A telephone T, make-and-break key K, a battery B and the microphone M are joined in circuit. The adjustment of the latter is now made, so that the ticking of the watch is heard as loud as possible in the telephone T, while the observer has one hand on the key K, and is also watching the spot of light at S.

It happens sometimes that microphones are uncertain in their action, and will suddenly fail to work, and in observing the spot of light during some such failures it was found that it jumped upwards at the moment when the telephone became silent, and returned as soon as the microphone was brought into action again by a tap on the table.

It was *only* during the clear working of the telephone that the spot of light remained steadily deflected downwards, which seems to indicate that during the time when the carbons are really in what is call microphonic contact they are not in contact at all, or at all events that there is a repellant action at the points of contact.

With a single element of a small bichromate battery in the circuit the deflection was hardly perceptible, but with three elements the spot of light moved through one millimetre between making and breaking.

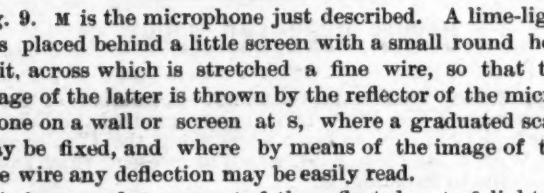


FIG. 9,

At the instant when the current is broken at K the spot of light moves upwards, not sluggishly but suddenly and sharply, the sound in the telephone of course ceasing at the same moment.

On making contact again the spot of light quite as suddenly returns to its former position, while the ticking is heard again.

The distance through which the spot of light moves is very small, but the action is so decided and unfailing that there is no difficulty in observing it.

When a greater number of elements was used the deflection was also greater, but there was much hissing, and the spot of light was not steady.

With three elements the experiment succeeded best; with this number the ticking of the watch could be heard loudly and clearly without any hissing.

In order to arrive at an estimate of the distance which appeared to exist between the two carbons at the point of contact during their action as a microphone, it may be mentioned that the distance between the screen S and the reflector was six metres, and that between the fulcrum and point of contact of the microphone six millimetres, so that the former distance was 1,000 times greater than the length of lever in the microphone. This figure has to be doubled on account of a reflected beam of light moving through double the angle of the reflector itself.

The total deflection on the screen S being one millimetre, the distance to which the upper carbon was repelled during microphonic action under the circumstances described was therefore $\frac{1}{2000}$th part of a millimetre.

Electric Lighting.—XXI.

ELECTRO-MAGNETIC PROPERTIES OF THE VOLTAIC ARC.

Since the voltaic arc is itself a conductor, and forms an intrinsic portion of the circuit, it is evident that it must have the same properties as a conductor carrying a current. It gives rise to lines of force just like any other conductor carrying a current, and therefore it can exhibit all the phenomena of magnetic attraction and repulsion. Thus, if we present a horseshoe magnet to the arc, it shows either an attractive or a repulsive influence, according to the relation of the lines of force that the magnet present to it. In either case the arc is bent out of its course one way or the other, the extent depending on the magnetic power exerted. Sometimes the arc may be bent so far in this manner as to break.

The magnetism of the earth may under certain conditions produce like effects, as for instance when the arc is produced between carbons disposed horizontally in a line at right angles to the magnetic meridian, so that the earth's lines of forces may react on those of the arc. The amount of curvature or displacement produced is influenced somewhat by this condition, for with the current in one direction the tendency is to repel the current from the earth upward and increase the bend, while with the current in the other direction the tendency is to attract the arc toward the ground and decrease the bend of the arc. This bend of the horizontal arc was once supposed to be a consequence of this magnetic effect of the earth exclusively; but it is now recognized as being a result of the heated air currents which displace it upward. It was shown at the beginning of these articles that two parallel currents attract or repel each other according to whether they follow the same or a different course; the arc also behaves according to this rule and can be attracted or repelled by means of parallel currents or another arc brought near to it. M. Jamin has indeed taken advantage of this fact in a most interesting way, for the construction of a "candle" for alternate currents which can relight itself automatically by such mutual attraction and repulsion.

CHEMICAL PROPERTIES.

One of the general properties of electrical currents is their power of determining and increasing chemical affinity. Thus, after a discharge of lightning the air is frequently filled with a sulphurous, pungent odor which is due to the ozone produced by the electrical discharge acting upon the oxygen of the air so as to condense it and enhance its properties. Frequently, also, the vapors of nitric acid are to be recognized at the same time in the air. These two products are also to be recognized in the voltaic arc occasionally, though the conditions which determine their production have not been determined. As these two agents both exert a purifying action on the atmosphere, it is evident that their presence is rather desirable than otherwise.

By the combustion of wood charcoal, gas, etc., a large amount of carbonic acid and watery vapor is generally produced and given off, but in the arc the combustion of the carbon produces only a small quantity of carbonic acid gas. In burning gas for the production of light a great quantity of this deleterious compound is produced. The heat of the arc is very intense, as already shown, but the volume of the flame is so small that the surrounding air is not increased in temperature very perceptibly. With gas it is the contrary; the amount of heat given off for the light produced is very much greater, as will be shown further, and, therefore, this, with the greater production of carbonic acid, renders the use of some means of ventilation a necessity in nearly all cases.

THE LIGHT OF THE VOLTAIC ARC.

The light of the voltaic arc is characteristic, both in intensity and color. It very much resembles the light of the sun in both of these respects, for it is possessed of the same dazzling brilliancy and whiteness of color.

Indeed, of all artificial lights that of the voltaic arc approaches most nearly to that of the sun in intensity. It has the same glowing ardor, and is similarly dazzling to the eye, which makes us compare it to sunlight. In reality, however, its intensity is not quite as great, as is readily shown by the fact that the impression produced on the retina of the eye by a glance at the sun will be more vivid and will last longer than that produced by a glance at a naked arc light. The intensity of the solar light is generally estimated at three times that of the arc light.

The light produced from any other artificial source imparts to the eye an idea of redness, or at least of yellowness, as contrasted with that of the sun, which seems white to our eye. The light of the voltaic arc, however, is an exception among artificial lights, because it does not give this conception of yellowness to the observer; on the contrary, it gives a conception of greater whiteness, or rather of "blueness," as compared with sunlight.

Now, the color of a given light is influenced by the character of the rays composing it. The quality of the light of the voltaic arc, therefore, must depend on the physical properties of its rays. Moreover, the amount of light evolved from a given source depends likewise on the conditions of these rays, and has of necessity an intimate relation to the heat present. We know that the hotter a body the greater the amount of light evolved, and we know also that beyond a certain point the light increases faster than the temperature. We shall see further on, that the energy given up by the current to the voltaic arc is not all transformed into light, for there is an important relation between heat and light that comes into play here and which modifies the economy of the light.

These two points, the qualities and the economy of the arc light, are, therefore, involved in the consideration of the characteristic properties of the rays evolved, and it will be interesting to enter into some details to make them more easily understood.

Light is caused by vibratory impulses or waves transmitted through the ether, just as sound is the result of similar waves transmitted through the air. The rays of light are all transmitted at the same velocity, but the waves of which they are composed are not all of the same size or amplitude of vibration. Some rays are made up of waves that oscillate in shorter periods, while others have waves which oscillate in longer periods. It is this difference of periodicity of undulation which causes the retina of the eye to perceive distinct colors, just as the change of rapidity or amplitude of sound waves gives rise to the distinct tones, the lowest tones corresponding to the slowest or longest vibrations and the highest to the shortest. C. O. M

A Visit to Beatty's Organ Factory.

Washington, N. J., boasts of an organ manufactory where a complete instrument is turned out every twelve minutes. It is owned by the Hon. Daniel F. Beatty, mayor of the city. The works and yards occupy thirteen acres. It contains 180 wood and iron working machines, 420 feet of line shafting, over two miles of leather belting, over seven miles of steam and water piping, three miles of electric wires, 320 Edison lights, 400 feet of speaking tubes, and a 500 horse-power engine, and it employs over 500 hands. The dust from the saws and planers is sucked up through tin funnels, carried to the engine room and used as fuel for the boilers. Everything is done to preserve the lives and health of the employés. Even the tuning of the reeds is done by steam. Fifty-five tuners are employed. Each is shut in a small cell by himself, where he listens to his monotonous music and nothing else during working hours.

Mr. Beatty asserts that he has the largest organ manufactory in existence. He claims that his instruments are of superior make and durability, and he challenges a trial with any other organ. His sound boards are of cedar, so constructed that a leak is impossible, and his reeds are dovetailed and as firm as though cut from a solid block of brass. While visiting Washington, last week, Mr. Beatty opened his books for the inspection of the writer. They showed the following receipts from the sale of organs and pianos in February:

Week ending Feb. 3.....$25,039	Week ending Feb. 17.....$21,759
Week ending Feb.10.....20,939	Week ending Feb.24.....26,184

The total for the shortest month of the year is $93,921, indicating a business returning nearly $1,200,000 a year. The books show that it is triple the business done in any previous February. In the twenty-four working days of last month, Mr. Beatty shipped 1,152 organs. He shut down for a week, in January, to put in a new boiler; yet he shipped in that month 1,102 instruments. In the twenty-six working days in December he shipped 1,410 organs, 980 in November, 1,303 in October, and 1,151 in September. His shipments of pianos are not included. They average about 100 a week.

Mr. Beatty is the largest tax-payer in Warren County. His manufactory cost him as it stands over $300,000. About eighteen months ago it was burned to the ground. In 120 days the present structure arose on the ruins of the old one. It is a third larger, yet its owner says that he is frequently driven night and day to fill his orders.

Mr. Beatty's business success seems to be due to three causes. He makes a first-class organ, sells it cheaper than others, and he lets the public know it. As he is his own agent, his customers get the percentages usually paid to agents. He is one of the heaviest advertisers in the country.—*N. Y. Sun.*

THE ELECTRIC LIGHT.

HOW "DYNAMO" SHOULD BE PRONOUNCED.—A correspondent of the English *Electrical Review* says that the big unclassical mouthful 'dynahmo' should be rejected and the word pronounced dynamo (dinnamo).

THE EDISON LIGHT IN CHICAGO.—The Western Edison Light Company has closed a contract for installing a plant of seventy lamps in the Merchants' National Bank building, Chicago, to be operated from machinery in the basement. This company is also pushing to completion a plant of seven hundred lamps in Haverly's Theatre and 250 in the American Express building.

AN EDISON COMPANY IN BOSTON.—The Edison Electric Illuminating Company of Boston was organized in that city on Wednesday, March 28, with Ex-Gov. A. H. Rice as president, W. L. Garrison as clerk and treasurer, and C. D. Stickney as general manager. The capital is $1,000,000. A central lighting station will be immediately established in the business portion of the city with a capacity of 20,000 lights.

ANOTHER EDISON COMPANY IN PENNSYLVANIA.—Some of the principal capitalists of Danville, Penn., have organized a new company, known as the Edison Electric Illuminating Company of Danville, with a capital stock of $50,000. Arrangements are being made to build a 200 horse-power engine and all the necessary equipments. The town has been paying extravagant prices for gas for several years, and this new enterprise is hailed with delight by the citizens.

LIGHTING THE WHARF AT PITTSBURGH.—The Allegheny County Light Company has agreed to give the city of Pittsburgh twenty lights on the wharf for $4,000 a year. A local paper thus figures up the saving to be effected by this measure: "The average cost will be $200 per lamp. As a gas lamp only gives a 16-candle light, while the contract with the Electric Light Company calls for 2,000-candle light, it will be seen that the cost of lighting the wharf with gas to the brilliancy which electricity will shed would have cost in the neighborhood of sixty thousand dollars."

TELEPHONE DEPARTMENT.

OHIO.—A new telephone company will soon extend its lines from Middletown, O., to neighboring towns, and also to Cincinnati and Dayton.

MR. VAIL IN CALIFORNIA.—Mr. Theo. N. Vail, general manager of the American Bell Telephone Company, is traveling in Southern California for the benefit of his health.

THE TELEPHONE AT READING, PA.—The Pennsylvania Telephone Company has recently introduced female operators on its lines in Reading, Pa., the only female telephone operators in that vicinity. It has now in Reading three male and two female operators.

TELEPHONING FROM NEW YORK TO CHICAGO.—The *Star*, of this city, of the 26th inst., is responsible for the following: The lines of the Postal Telegraph were opened between this city and Chicago yesterday for a private test. The wire showed a resistance of only 1,522 ohms as against over 6,000 ohms on the best iron wire, and 15,000 ohms on the average of the iron wires. Conversation was carried on between New York and Chicago, a distance of 1,000 miles, as distinctly as between any points within this city, this being the greatest telephonic feat on record.

A District Telegraph Company in Rio de Janeiro furnishes messenger, police, fire-alarm and *telephone* service. The company is meeting with a very satisfactory reception from the Rio public. Its officers are C. P. Mackie, president; W. J. Doushea, general superintendent and electrician, and Victor Diaz, manager. Mr. Mackie is the attorney in Brazil of Professor Bell, and the founder of telephony in that empire; the government having given the first concession in 1879. Mr. Doushea was sent out by the Continental Telephone Company in 1880 to erect the exchanges established under this concession.

THE MOLECULAR TELEPHONE.—This instrument, the property of the New York Molecular Telephone Company, is triangular in form, the hypothenuse being placed outward and containing the diaphragm. The entire instrument could be covered by an ordinary stiff hat. The diaphragm covers almost the entire front of the telephone, and consists simply of a thin piece of cork resting on a hub of carbon, from which spokes of carbon spread in every direction. The instrument seems to have been built on the reserve plan, one interior breakage having no perceptible effect upon the general workings.

EXTENDING THE TELEPHONE IN NEW JERSEY.—The New Jersey Telephone Company, recently organized at Freehold, has commenced the building of a telephone line from Long Branch to Freehold, taking in the towns of Red Bank, Seabright, Eatontown, Shrewsbury, Asbury Park, Keyport and South Amboy. When completed, this line will make direct connection with New York, Brooklyn and Westchester County, New York State, and the whole northern portion of New Jersey, embracing a territory within 45 miles of New York City. All the summer hotels at Long Branch, Red Bank, Elberon, Seabright, Asbury Park, Ocean Grove and Spring Lake will be in connection with this new telephone line.

NEW TELEPHONE RELAY AND LOUD-TALKING RECEIVER.—An interesting feature of a series of experiments made here on the 22d inst., by the National Secret Telephone Company, in telephoning to Cleveland, was the employment for the first time of a telephone relay, receiving the words in a local circuit, after the fashion of a Morse sounder, so that the reënforcement of the electric current increased the volume of tone at the receiver. Another new thing, the invention of Mr. C. A. Randall, general manager and electrician of the National Secret Telephone Company, was a loud-talking receiver. In receiving messages from Cleveland, although the instruments were not perfectly adjusted for so great a distance, words were heard distinctly with this receiver at a distance of six or eight inches from the ear.

TELEPHONE OFFICES AT LOWELL.—The executive offices of the Lowell syndicate will soon be removed into their new apartments in the post-office building, where they will occupy the entire front of the third floor. The telephone central office will remain in the upper story of Shattuck's block, where the company have the finest operating rooms in the country. The telephone arrangements at the new executive office will be complete in every respect. The president, treasurer and general manager will have apparatus on their desks by which they can talk directly with any important points in and out of town without calling the central office, and in addition there will be a series of signals that will summon the various clerks. The company, with their operating and supply departments, will occupy fifteen rooms.

AN ENCOURAGING OUTLOOK.—A gentleman connected with a prominent manufactory of telephone and telegraph instruments who was interviewed by a newspaper correspondent in Washington last week remarked: "The telephone industry is growing like Jonah's gourd. Within the past month I have been over nearly the whole of the Union, and I find the use of telephones increasing so largely that the manufacturers are unable to supply the demand. Within the last six weeks I have taken orders for our factory alone for 6,600 telephone bells, and I will sell 10,000 more within the next month. The demand for the coming spring promises to be the largest ever known in the history of the telephone. We have orders enough now on hand to keep us busy for two years, and we are increasing our capacity every year. There are five other factories in the United States making the Bell telephone, and they are all doing well."

HOW THE TELEPHONE IS EXTENDING—At present there are more telephones in New York than in any other city in the world, and the number, it is said, has been increasing at the rate of twenty a day for the past year. Boston, Chicago, Baltimore, Cleveland and Cincinnati are now putting in over fifty new telephones every month, and Nashville is increasing its subscribers at the rate of two per day. The villages are establishing exchanges, and it is predicted that the time will come when the major part of the houses throughout the country will be connected by telephone. The business is being pushed in Europe as well as in America, but foreigners are so slow to take up new things that there is not now one telephone in England to one hundred in America. In France the telephone is used by some of the larger business houses, but as a convenience for the people it is almost unknown. In the other countries of Europe it is much the same. The people didn't seem to understand the value of the invention, and they don't take hold of it as the Americans do.

NUMBERING THE SECTIONS.—In rearranging the Portland, Me., exchange, the number system is being remodeled and arranged in a manner that will, it is believed, insure rapid work and give Portland subscribers the benefit of one of the most perfect systems of central office work in the country. Instead of each section of one hundred wires being designated by a letter, as in other exchanges, each section will be known in the office by its hundred number. The first section will contain subscribers up to one hundred and will be known as section 0 (cipher); the next section is 1, the next 2, and so on; so every subscriber is on the section which corresponds with his hundred number, and the operator knows exactly, quickly and without a thought on which section to find any subscriber. As it has been found by experience that 20 and 30 or 21 and 31, etc., are often mistaken by telephone, all thirties are thrown out. For the same reason number eleven, which is often confounded with seven, is omitted.

THE PORTLAND EXCHANGE.—The new operating room of the Portland, Me., exchange, which is now completed, is large, airy, light and will enable the company to give the citizens of Portland better service than was formerly possible. The new switch-board has several novel features and improvements, which, it is said, are introduced in Portland for the first time. At present the switch has twelve sections, with room to add more as required. In no case are there more than forty wires on any section, and those having the busiest wires are arranged for only twenty-five wires. Among the new features are a device for connecting different sections together, when the regular connecting strips are all occupied, and a supplementary switch, the use of which is to easily and quickly change any battery in use in the central office that may have become weak to a new or spare battery. Nineteen new subscribers have been added to the Portland exchange during the present month.

BAXTER AND HIS NEW TRANSMITTER.—Much interest is taken in the Baxter transmitter, by which long-distance conversation by telephone is made possible. Mr. Lester Baxter, the inventor, is a clerk in the Surgeon General's office, at Washington. He has been a devoted student of electricity for many years and has made numerous discoveries which have not yet been brought to practical use. In reference to his transmitter he says that one of the most important differences between his invention and the Blake is that whether the speaker talks in a whisper or shouts close to the diaphragm the same is heard equally well through the Baxter transmitter, while a loud tone spoken to the Blake transmitter will so agitate the current as to make hearing an impossibility to each other by wire. The company controling this patent do not intend to construct their own lines, but will lease privileges and instruments to telegraph companies. The company already have many offers for exclusive rights, and are now considering a proposition for the entire territory of New England. Arrangements are making for a further test of the invention between New York and Washington.

A PUFF FOR THE PEOPLE'S TELEPHONE COMPANY.—The Boston *Transcript* of a recent date says: "The People's Telephone Company, owning the Drawbaugh patents, is making a much stronger case against the American Bell Telephone Company than it was expected it could do when the litigation began. At first the claims of Daniel Drawbaugh, of Eberly Mills, Cumberland County, Pa., that he had invented a 'talking thing' before Bell were laughed at, but the testimony now being presented at Washington is said to have been surprisingly strong. There are indications that the Bell Company will buy up this opposition, which has thus far proved the strongest the Bell Company has met with since the settlement of its great fight with the Western Union Telegraph interest. The People's Company has a capital of $5,000,000, divided into 100,000 shares of a par value of $50 per share. The stock has been kicked about at from $2 to $3 per share until lately, when it suddenly sold above $10 per share." Those connected with the American Bell Company who are in a position to know profess to pooh-pooh this. They say that the Drawbaugh case does not cause the American Bell any uneasiness.

THE MOLECULAR TELEPHONE.—The molecular telephone, by means of which the New Yorker is soon to speak with Chicago, a thousand miles away, is described as differing from all other telephones in the substitution of molecular action for mechanical vibration in the transmission of sound. The transmitter of the telephone instead of being a metallic vibrating plate is a carbon microphone, imbedded in and completely covered by cork, although wood, cardboard or any non-resonant material can be used. The receiver is a magnet surrounded by insulated wire at one of its poles, a continuation of which is made to tap against a plate of cork or any other substance that is free from inductive action by the variations of the current, its operation being similar to that of the sounders which are so extensively used in telegraphy. The cork absorbs the sound waves, thus producing within its substance molecular disturbance, by means of which the words spoken at the transmitting end are reproduced in a distinct manner without any confusion of syllables or liability to error in words in which sibillations occur. The molecular action ceases by the absorption of the sound waves as soon as the words transmitted are reproduced, and this, without reaction, produces perfect articulation. The officers of the Molecular Company claim that the telephone can be produced one-third cheaper than the ordinary instruments.

TELEPHONE MILLIONAIRES.—The correspondent who interviewed the electrician in Washington last week, particularly in reference to telephonic subjects, was told by that well-informed gentleman that "nearly every man who has been largely interested in telephones has become wealthy. All of the original company of the Bell invention, with perhaps a single exception, are now millionaires. Bell himself is worth about six million dollars. His income is very large, and increases every year with the extent of the business. He is a dark-complexioned man, between thirty-five and forty years of age. He talks with an English accent, and has a keen eye for business. Attempts are being now made to break down his patents, but it is questionable whether they succeed. Thomas Watson, the old gray-haired mechanic who used to help Bell in his experiments, had a little shop in New Haven, and made electrical instruments. Bell would give him his ideas of what he wanted, and the two would experiment together until the proper result was reached. When the company was organized Bell made him general inspector for the United States. He is now a millionaire, and his family are traveling in Europe. Marshall Jewell was largely interested in telephones, and made a great deal of money by them. H. P. Frost, president of the Connecticut Telephone Company, has laid up a million within the last few years, and George W. Coy is also a millionaire.

1,000 MILES BY TELEPHONE.—On Wednesday last experiments were made over the Postal Telegraph Company's wire in telephoning between this city and Chicago, a distance of about 1,000 miles. The instrument was the double Edison telephone, which was employed four years ago in establishing communication between Toledo and Milwaukee, by way of Detroit and Chicago, a distance of over 500 miles. It consists of two Edison telephones attached to a single mouth-piece in such a manner that one can talk into both at the same time and get their combined effect upon the line connecting the two. It seems to matter little, however, what instrument is used, for the various experiments that have been made with different points at a great distance have all been attended with similar results. It is thought, therefore, that the great success attained must be attributed to the compound copper wires of the Postal Telegraph Company, through which the sounds are transmitted, of which the conductivity is about seven times as great as that of ordinary steel wire. They consist of a core of steel surrounded by a coating of copper, so combining the strength of the ordinary wires with the conductivity of the copper covering. With these wires there appears to be no limit to the possible use to which telephones can be put. Every word that was said could be heard as distinctly as when using the wires that run from office to office in this city, and the operators in Chicago were able readily to distinguish the voices of the gentlemen in the New York office.

DASHES HERE AND THERE.

THE EDISON TELEGRAPH COMPANY.—A number of leading citizens of Van Wert, Ohio, have organized the Edison Telegraph Company, to build a line along the Cincinnati, Van Wert & Michigan road, which at present runs from Greenville to Paulding, O.

THE COLUMBUS, O., TELEGRAPHER'S BALL.—The reception and ball of the Columbus telegraphers on Monday evening, March 26, was a very successful and enjoyable affair, although the weather was unfavorable. Several visitors were present from other cities.

THE AMERICAN RAPID IN CLEVELAND.—The American Rapid Telegraph Company is now open for business in Cleveland, O., at No. 84 Superior street, in the Atwater block. Mr. John H. Simmons, lately assistant chief operator of the Western Union, is manager of the Cleveland office.

A TELEGRAPHIST'S SAD DEATH.—Mr. John Zimmerman, formerly a train dispatcher on the Pittsburg division of the Baltimore & Ohio Railroad, was found dead on the street in Connellsville, Pa., shortly after daybreak on March 23. His pockets had been rifled, but there were no other indications of violence.

PENNSYLVANIA'S ANTI-CONSOLIDATION BILL.—A Harrisburg (Pa.) dispatch says: The Western Union has fully determined to antagonize the Hall bill, which escheats to the State the property of any telegraph company that has consolidated with a competing line since the adoption of of the new constitution in 1874, or which shall hereafter consolidate.

ELECTRICAL ENGINEERING AT CORNELL UNIVERSITY.—At a meeting at Ithaca, N. Y., on Monday last, the 26th inst., the trustees of the Cornell University authorized the establishment of a course in electrical engineering on the opening of the new physical and chemical laboratories in September next. A very extensive collection of apparatus has been received for the purpose.

A POSTAL TELEGRAPH COMPANY FOR NEW YORK STATE—The American Postal Telegraph Company was incorporated at Albany, March 28. The new company is formed for the purpose of buying, constructing, owning, using, and maintaining a line or lines of electric telegraph throughout the counties, towns, villages and cities in the State of New York; capital stock, $5,000,000.

T. M. B. A. ASSESSMENT.—Assessment No. 163, dated April 2, has been issued by the Telegraphers' Mutual Benefit Association. It announces the death of Mr. Luther H. Lathrop, of this city. One dollar is due to meet this assessment from members holding certificates up to and including 4449. Forty-five new members have joined the association, first division, and three the second, since last assessment. Mr. Lathrop suddenly dropped dead in the street about six o'clock in the evening of March 19 of neuralgia of the heart.

REVENUE OF THE ENGLISH POSTAL TELEGRAPHS.—The London *Telegraph* says: By a Parliamentary paper it appears that the gross amount received by the Post-Office Telegraph Department during the year ended March 31, 1882, was £1,882,355, while the value of telegraph services performed for other public departments without remuneration was £21,920. The amount expended in respect of salaries, rent, maintenance of telegraphs, etc., was £1,365,632, and the balance to meet interest on stock created on account of the telegraph service and the redemption of debt was £218,892. There was a deficiency of telegraph revenue in the year to meet interest on telegraph stock created of £112,521.

ELECTRICAL ENGINEERING AT COLUMBIA.—An effort is being made to establish a school of electrical engineering in connection with Columbia College. The cost of the plant necessary for such a school will be $15,000, and the expense of maintaining the school will amount to $25,000 annually. Mr. Edison first suggested such a school to the trustees, and he is most interested in its establishment. The officers of some of the telegraph, telephone and electric lighting companies have been conferred with in regard to the matter, and expressed the belief that the graduates of such a school could be of much assistance to them. The trustees do not feel like assuming the entire expense

of such a school; but if the electrical companies will furnish the plant and guarantee $12,000 a year toward the expense, they will organize the school, making the course complete and the instructions thorough. It is stated that they have reason to believe that this offer will be accepted.

STOCK QUOTATIONS.—Telegraph, telephone and electric light stocks were quoted on Wednesday of last week and Wednesday of this week as follows:

	March 21.	March 28.
Western Union Telegraph	82¼	82⅝
Mutual Union Telegraph	18½	18
American Cable	65	65
American District Telegraph	30	....
Edison Electric Light	....	350
U. S. Electric Light	131½	131
Fuller Electrical Co.	....	32
Mexican Telephone	4	3⅛
Tropical Telephone	....	2¼
American Bell Telephone	282	276
Bay State Telephone	....	125¾
Northern Telephone	....	144¾
Central Mexican Telephone and Tele..	35	....
Hudson River Telephone	105	....

THE NEW WESTERN UNION PAYING ITS RESPECTS TO THE OLD CONCERN.—State Attorney Luther Laflin Mills. of Illinois, on the relation of Allan O. Storey, Harvey S. Hayden and Allan C. Knapp, filed in the Superior Court in Chicago on the 21st inst. a petition for leave to file an information in the nature of a *quo warranto* against Robert C. Clowry, Frederick H. Tubbs, W. K. Morely, Frank C. Ives, Norman Williams and John L. Thompson requiring them to appear in court and show by what authority they exercise the rights of a corporation and carry on the business in the State of Illinois under the name of the Western Union Telegraph Company. The petition says the respondents claim to have acquired the right in the State of New York, but it says no matter what authority was given them in New York they have no authority to exercise those rights in Illinois. They cannot lawfully exercise them until they have complied with the requirements of the laws of Illinois. Moreover, even if they ever had any such rights they have forfeited them. Judge Smith granted the petitioner leave to file his information, which he did instanter, and a summons was issued for the respondents, returnable on April 1.

REIFF VS. THE WESTERN UNION.—On Tuesday last, the 27th inst., Judge Freedman gave his decision upon the motion to continue the preliminary injunction granted in the suit of Josiah C. Reiff against the Western Union and Mutual Union Telegraph companies restraining the consummation of the lease to the former company of the lines of the latter. In this decision the Judge says:

"The failure of the Western Union Company to obtain the consent of the requisite number of its stockholders at a general meeting duly called for that purpose, constitutes a defect, but the only defect, in the proceedings taken for the acquirement of the lines of the Mutual Union Company. In consequence, the plaintiff, as an aggrieved stockholder in the Western Union, is entitled to have the injunction against the consummation of the lease and the payment of the consideration, or any part thereof, continued pending the action. Leave, however, should expressly be granted to the Western Union Company to convene a general meeting of its stockholders for the purpose of procuring the consent to the lease of the requisite number of the stockholders in the manner required by the statute, and the order should provide that if such consent is obtained, on the proof of such fact any of the defendants may at any time thereafter apply for the dissolution of the injunction."

THE DAFT ELECTRIC MOTOR.—Mr. Leo Daft, a graduate of London University, claims to have perfected an electric motor which will soon supersede horse-power on our street railways. His experimental line is at Greenville, N. J., and is about one-eighth of a mile in length, with one very sharp curve and with a heavy grade, and is laid as an ordinary steam railroad track. The electricity is generated by a powerful dynamo machine, which is also one of Mr. Daft's own construction. It is carried to the rails, through which it runs, a perfectly harmless current. The motor consists of a simple pair of trucks as a basis. Under a platform above the trucks the electrical appliances for regulating the motor are placed, and occupy so small a place that they are hardly noticeable. By a small lever the motor is regulated in speed and the brake is put on. There is another small lever attachment, by turning which the weight of the motor is practically increased, so as to give the adhesive power necessary in heavy grades, and by which a grade of 40 degrees can be ascended. Mr. Daft gets his power from a 50 horse-power steam engine, which also runs the dynamos furnishing the current for the electric motors. In regard to the cost of running cars by electricity, Mr. Daft claims that he could regain 75 per cent. of the energy exerted from the steam engine in running the dynamo, and that he could run the motors 40 per cent. cheaper than by steam. He proposes, he continued, to divide the line of track upon which the electric motor shall run into stations of 25 miles, at each station being a dynamo of the necessary power. On street railways a more favorable showing could be made. The cost of the motor itself would be small in comparison with steam engines, and there would be no need of relaying or changing the present tracks of the street railways and no third rail would be needed. The loss of electricity in the system was very small and only appreciable by delicate instruments. Any number of motors can be run independently on the same track.

NEW YORK CITY ITEMS.

Echoes from 195.

Mr. S. M. Austin, from the Central Cable Office, is now working at 195.

Henry Rath, of the Newark, N. J., wire, has gone to Jacksonville. Fla.

Mr. M. O'Brien, of No. 22 South, is detained at home with a badly inflamed eye.

Mr. Glover, who has been on the Wheatstone staff in Chicago, has returned to New York.

Mr. J. F. Cleverdon, of the Baltimore quad. will represent Mr. Miller during his two weeks' absence.

Mr. J. E. Miller, formerly of 195, now operator for Kidder, Peabody & Co., has gone to Savannah, Ga., to recuperate his health.

There is now a chance that the scaffolding may be taken down within a few weeks. The painters are at work on the ceiling. Iron hooks have been inserted all over the ceiling at intervals of about 8 feet, from which scaffolding will be suspended when repairs again become necessary, thus obviating a repetition of the present cumbersome arrangement.

Mr. Mort. Duperow, inspector of the gold and stock department of the G. N. W. Telegaph Co., Toronto, Ont., was in New York last week investigating the methods of working the stock indicators in use in this city. Mr. Duperow visited 195 and was warmly welcomed by his old friends, Messrs. D. B. Mitchell, John McClelland, Jas. Hurley and Arthur Waldron, who endeavored to make his stay in the metropolis both pleasant and profitable.

Messrs. Harry Hues, E. P. Griffith and Court Cunningham are the gentlemen who manipulate the New Orleans circuits. On the ceiling cornice directly above the New Orleans' desks, there are specimens of various styles of fresco painting, one of which will probably be chosen as a pattern for the entire room. Mr. Hues favors the Etruscan style, Mr. Griffith is partial to the æsthetic, while Mr. Cunningham is undecided as between the Westlake and Celtic styles.

A few evenings ago an ex-employé of 195, while in an intoxicated condition, obtain access to the coat-room, and without cause violently assaulted a gentleman connected with the operating room. The assailant was arrested, and although witnesses appeared against him, the following day he was discharged, the Police Court Justice remarking, "this was no place to bring such cases!" This is the third time within as many months that intoxicated persons have obtained entrance to the building and behaved outrageously.

Other City Items.

Mr. John Lenhart has changed his location and is now with the Western Union at the Produce Exchange, "C X," this city.

Judge Wallace, of the United States Circuit Court, has dismissed the motion for an injunction in the matter of the lease or sale of the Gold Stock Telegraph Company to the Western Union. This decision affirms the validity of the lease.

A grand masquerade ball will be given on Tuesday evening, April 3, at Lyric Hall, by the telegraphers of the American Rapid Telegraph Company. Mr. E. W. Venable, president of the ball; Mr. A. J. Murren, treasurer, and Mr. M. J. Dixon, secretary.

On Wednesday last, the 28th inst., Judge Barrett, in the Supreme Court, granted a stay of proceedings to allow of an appeal from the decision recently rendered declaring that the poles of the Metropolitan T. & T. Co. in Twenty-first street are a nuisance to the public and must be moved.

Mr. H. J. Pettengill has retired from the management of the American Rapid office at Boston, and assumed a similar position with the same company, at New York. The employés at Boston expressed their esteem by presenting him a beautiful watch and chain. Mr. E. B. Pillsbury succeeds him as manager at Boston, and Mr. Selden Crowe takes the position of chief operator, made vacant by Mr. Pillsbury's advancement.

On Tuesday last Mr. Jay Gould returned from his trip to Florida. He says he enjoyed his brief vacation. A correspondent on one of the railroads over which Mr. Gould traveled in his private car, sends us the following soliloquy, which shows how the lives of men whose death would cause a commotion in the world are often in the hands of a telegraph operator: "I've got to slide Mr. Gould down to the Everglades or thereabouts in safety. I don't like the responsibility of so much money. If I should make a mistake and put his car in the Ogeechee by the sudden contact with an east-bound train! Well??? It is kind 'o funny when you come to think of it! Some of Mr. Gould's enemies might be willing to give a million to be train-dispatcher to-day! I never thought I would have Jay in my power. But such are the vicissitudes of life!"

At the meeting of the New York Electrical Society, held on Friday evening, March 16, the election of officers for the ensuing year was completed, the following named gentlemen being chosen:

1st Vice-President, George B. Scott; 2d, Prof. P. H. Vander Weyde; 3d, J. D. Reid; 4th, E. C. Cockey; 5th, W. J. Johnston; 6th, Gerritt Smith.

Recording Secretary—Thos. R. Taltavall.

Financial Secretary—J. McKenzie, Jr.

Treasurer—F. W. Jones.

Four additional members of the Executive Committee: Gerritt Smith, E. C. Cockey, E. L. Bradley, and H. L. Bailey.

Mr. C. S. H. Small was elected president at the previous meeting of the society.

A meeting of the society will be held in its rooms, corner Greenwich and Liberty streets, at 8 P. M., Friday, April 6.

Mr. F. W. Cushing will describe the latest developments in Harmonic Telegraphy, and a paper on Cable Testing, by Geo. A. Hamilton, will be read.

Both of these subjects were postponed from last meeting, owing to the lateness of the hour at which the election of officers was completed.

On Friday, April 20, the society will meet at the Stevens Institute of Technology, Hoboken, N. J., when Prof. Henry Morton will address the meeting on the "Storage of Electricity."

PERSONAL.

BROOKLYN, N. Y.—Mr. F. C. Mason, formerly of the Long Island Telephone Company, has been appointed manager of the American Rapid Company's office in Brooklyn.

The B. & O. Telegraph Co. having closed its Boston office, Mr. J. H. Clarke, who was in charge, has accepted a position with the American Rapid at 105 Summer street, *vice* Mr. G. H. Winston, transferred to main office.

Mr. Charles G. De Moll, an operator and journalist, and at one time agent of the American Press Association at Philadelphia, died at his home in that city on Thursday, the 22d inst., after a short illness. He will be remembered as the leader of the "Franklin Strike," 14 years ago.

CINCINNATI.—Mr. George A. Love, for the past ten years chief operator in the general offices of the Marietta & Cincinnati Railroad, has tendered his resignation. Mr. Love retires from the service of the road to go to Greenfield, O., where he will engage in commercial business.

LYNCHBURG, VA.—Mr. Robt. L. Sneed, for several years an operator in the Western Union office in Lynchburg, Va., has resigned to take charge as manager of the office of the Southern Telegraph Company, just opened in that city. Mr. Sneed is well known to Southern operators and is exceedingly popular in and out of the fraternity.

Mr. Samuel W. Bigger, manager of the telegraph office in the Kansas City, Mo., Union depot, is dead. At the funeral which was largely attended, the coffin was laden with floral tributes, including a handsome column from the operators of the Western Union Telegraph office. Mr. Bigger's death caused a general sorrow among a large circle of friends.

NOTES FROM READING, PA.—Mr. C. M. Dechant, for a long while connected with the Auditing Department of Supt. O. W. Stager has resigned to accept a more lucrative position in the chief engineer's department of the canals controlled by the Philadelphia and Reading R. R. Co. Mr. E. C. Rungeon, formerly entry clerk in the main office, has been transferred to the Auditing Department. Mr. Edward Wright, formerly, of Pottstown, succeeds Mr. Rungeon as entry clerk at the main office. Mr. Frank Ewing, formerly assistant at Pottstown, succeeds Mr. Wright at that place.

SAVANNAH, GA.—The Western Union city office is ably managed by His Honor, "Judge" B. F. Dillon, assisted by Harry Zeigler and Messrs Dundon, Casey, E. B. King, Frank Hernandez, C. S. Smith (late of Buffalo) Richard Kain and J. A. Storer. This bouquet of talent is hard to beat. We have, however, in S., F. & W. Ry., Messrs Dunn, Boatright, Buckley, Benton, Keegan, McCowan and Baer. That is a big force for a railroad, but it's a big railroad. At the Georgia Central we have Mr. John English and Mr. Terrell. Our late manager, Mr. H. Griffith, is in charge of the telephone service here. Perhaps it will be gratifying to conclude by saying that the Brotherhood is prospering.

Mr. John Henry Pearce, manager of the telegraph office and also of the telephone exchange in Clarksville, Tenn., died at that place March 22d. Mr. Pearce was 45 years of age, and had been manager at Clarksville fourteen years. He was prominently identified with telegraph service in the late war. Many years ago, while employed on a railway in Ohio, where the night operators were required to send in their calls and report on duty every half-hour, he invented an attachment which connected the clock with the wire and sent in his calls as regularly as the time arrived, so that he could enjoy a sleep undisturbed. No matter what else was transpiring over the line this little machine would fire in its reports, and operators soon learned the trick and recognized the call as Pearce's old clock; but so popular was he with the company and operators that no objection to the little helper was interposed. He also invented another instrument which, attached to the railroad track, registered the number of cars that passed over the road during the night—a record he was required to keep.

ELECTRICAL PATENTS ISSUED.

Week ending March 20, 1883.

Apparatus for substituting gas for electric light; Patrick B. Delaney, New York	274,181
Cut-out for dangerous electric currents; Frederick A. Swan, and Charles B. Bosworth, Boston, Mass	274,150
Circuit controller for electric clocks; Vitalis Himmer, New York	274,323-4
Circle switch for galvanic batteries; Henry Lowe, Brooklyn, N. Y.	274,452
Dynamo-telegraphy; Henry Van Hoevenbergh, Elizabeth, N. J	274,417
Electric cut-out; Frederick A. Swan and Charles B. Bosworth, Boston, Mass	274,151
Electric lamp; Thomas A. Edison, Menlo Park, N. J	274,293
Electric lamp cut-out; John H. Elfering, Chicago, Ill	274,297
Electric clock; Vitalis Himmer, New York	274,325
Electric telephone transmitter; James A. Maloney, Washington, D. C	274,353
Electric current regulator; Charles G. Perkins, Camden, N. J	274,371
Electric arc lamp; Charles G. Perkins, Camden, N. J	274,370
Electric arc lamp; Elihu Thomson, New Britain, Conn.	274,413
Electric clock escapement; Adelbert W. Gray, New York	274,445
Galvanic battery; Felix de Lalande, Paris, France	274,110
Incandescing electric lamp; Thomas A. Edison, Menlo Park, N. J	274,294
Incandescent electric lamp; Thomas A. Edison, Menlo Park, N. J	274,295
Incandescent lamp holder; Edward Weston, Newark, N. J	274,427
Manufacture of incandescents; Thomas A. Edison, Menlo Park, N. J	274,296
Printing telegraph; Stephen D. Field, New York	274,300
Printing telegraph; Henry Van Hoevenbergh, Elizabeth, N. J	274,416
Receiving telephone; James A. Maloney, Washington, D. C	274,352
System of electric distribution; Thomas A. Edison, Menlo Park, N. J	274,290
Secondary battery; Thomas A. Edison, Menlo Park, N. J	274,292
Secondary battery; Jas. Pitkin, Clerkenwell, County of Middlesex, England	274,373
Telegraph apparatus; Georges D'Infreville, New York	274,112
Telegraph and semaphore signal; William W. McLellan, Newcastle, New Brunswick, Canada	274,212
Telephonic transmitter; Clement Adder, Paris, France	272,246
Underground conduit for electrical conductors; Henry Robert Meyer, Liverpool, County of Lancaster, England	274,218

BUSINESS NOTICES.

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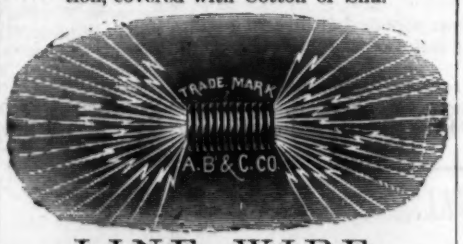

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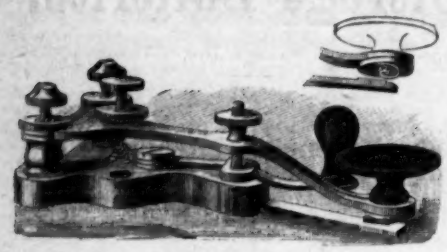

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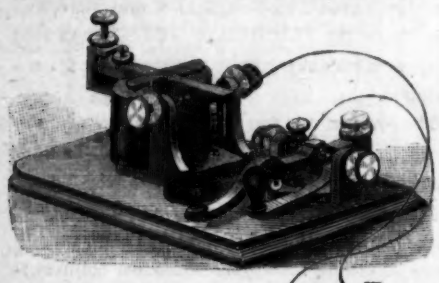

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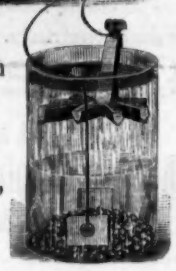

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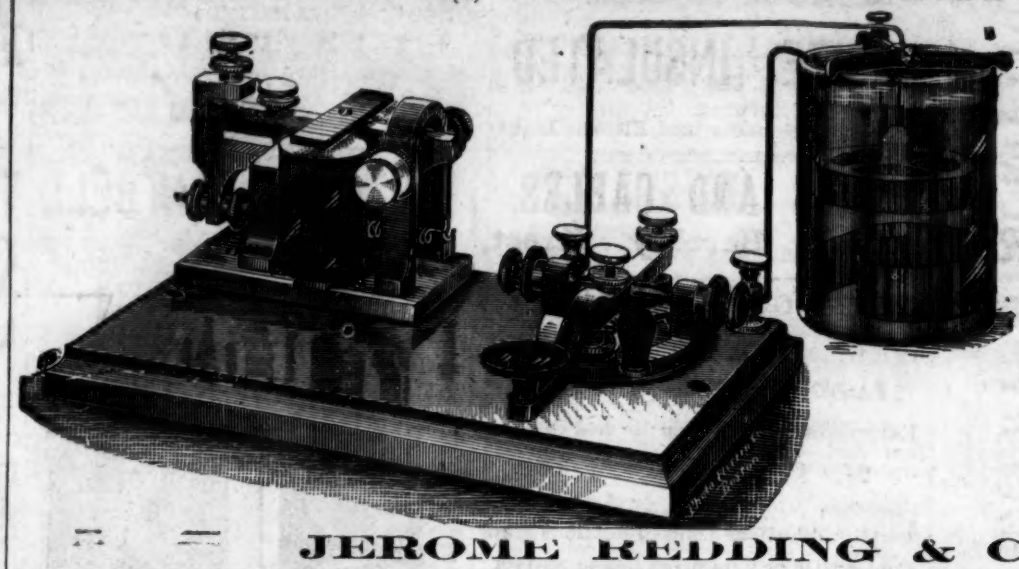

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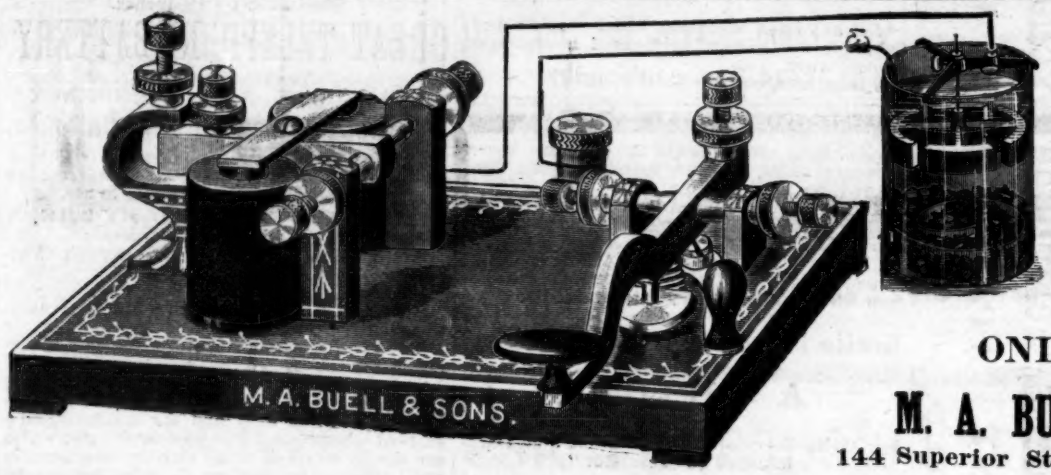

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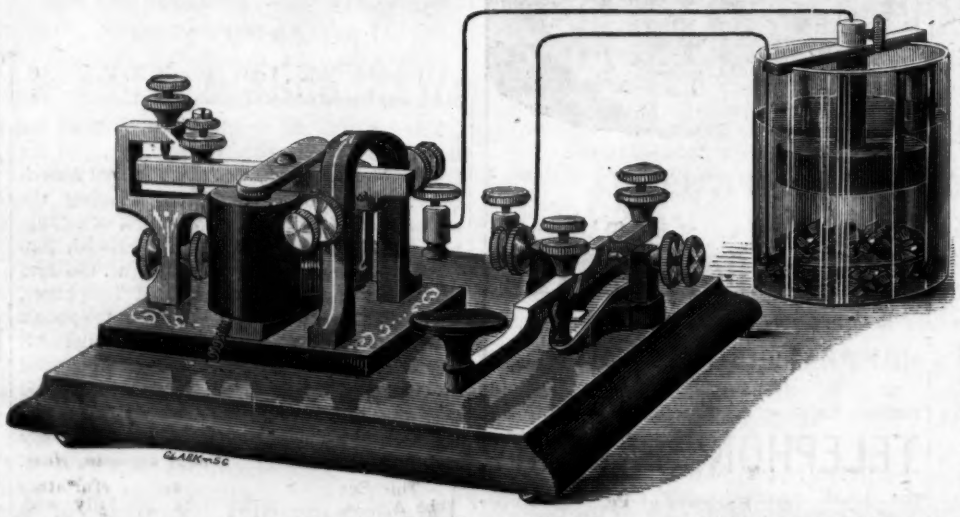

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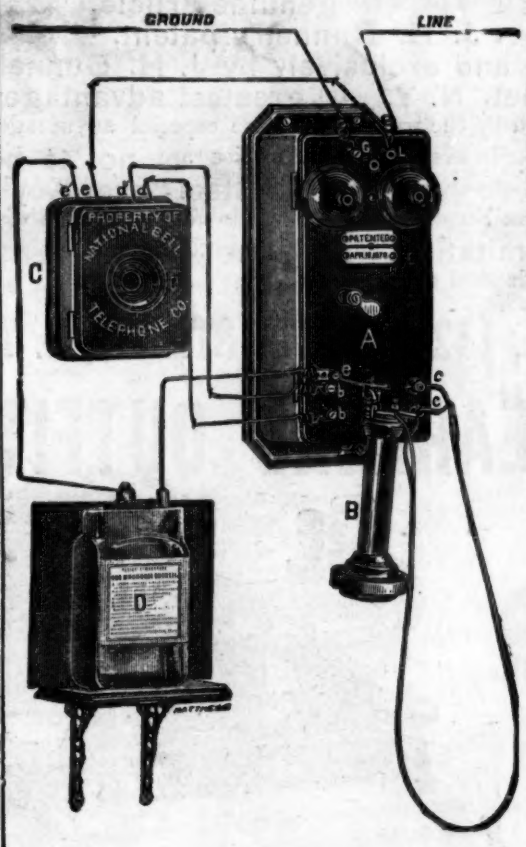

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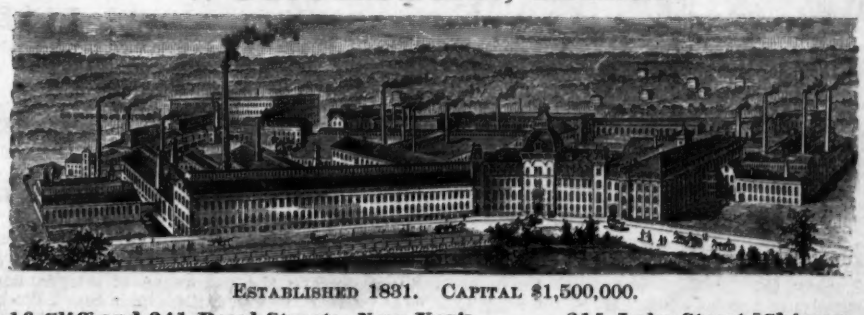

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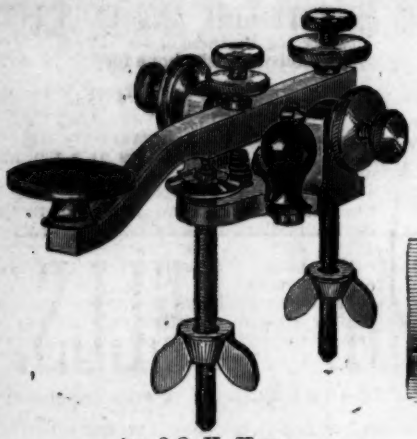

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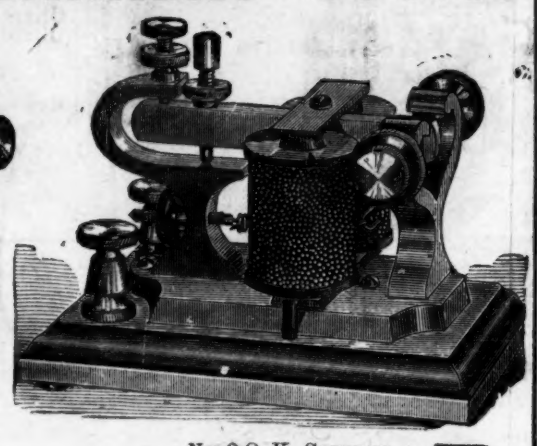

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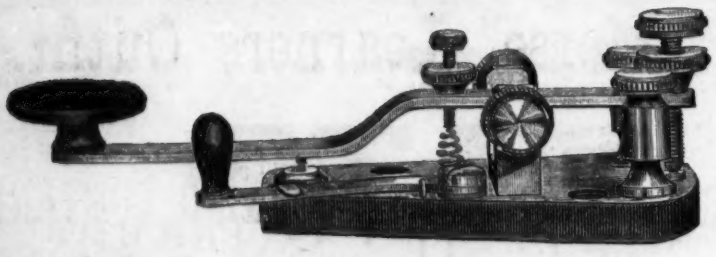

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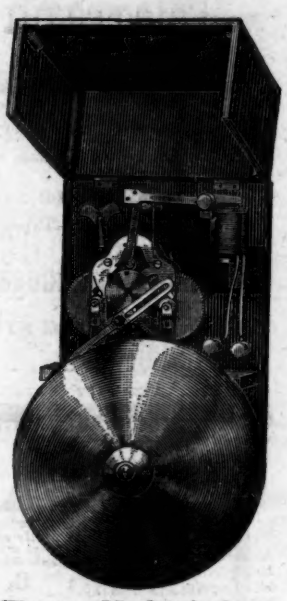

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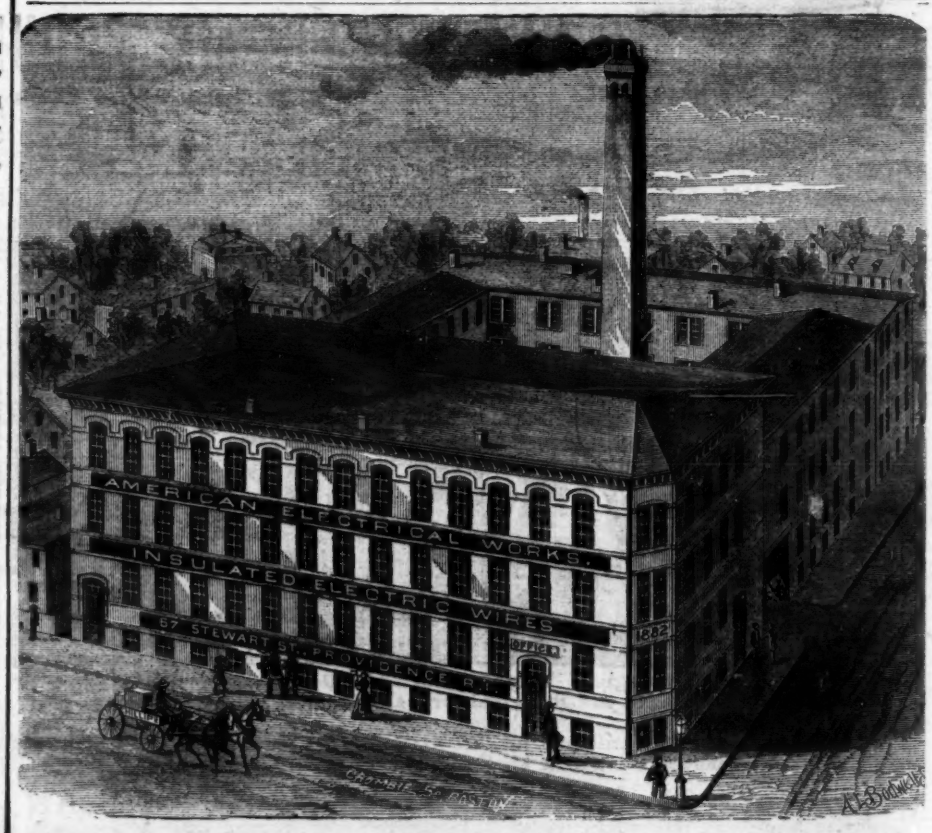

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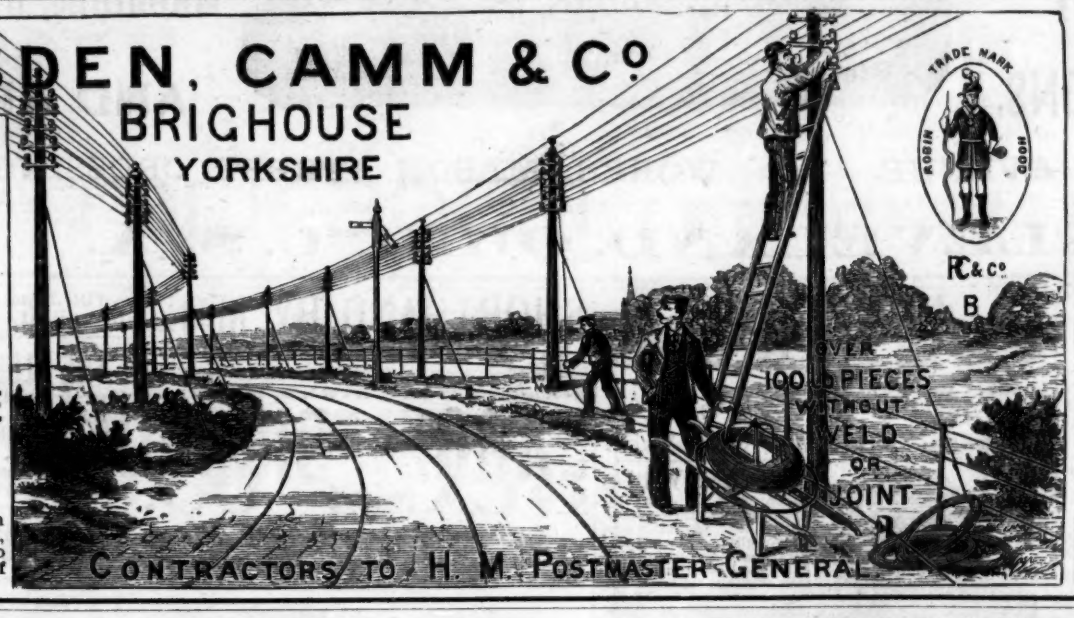

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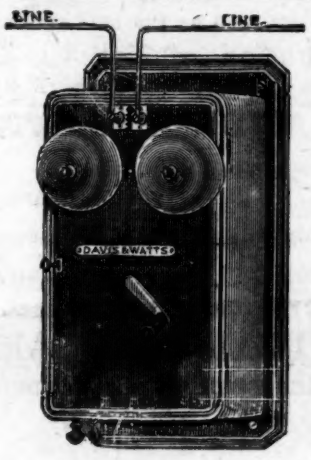

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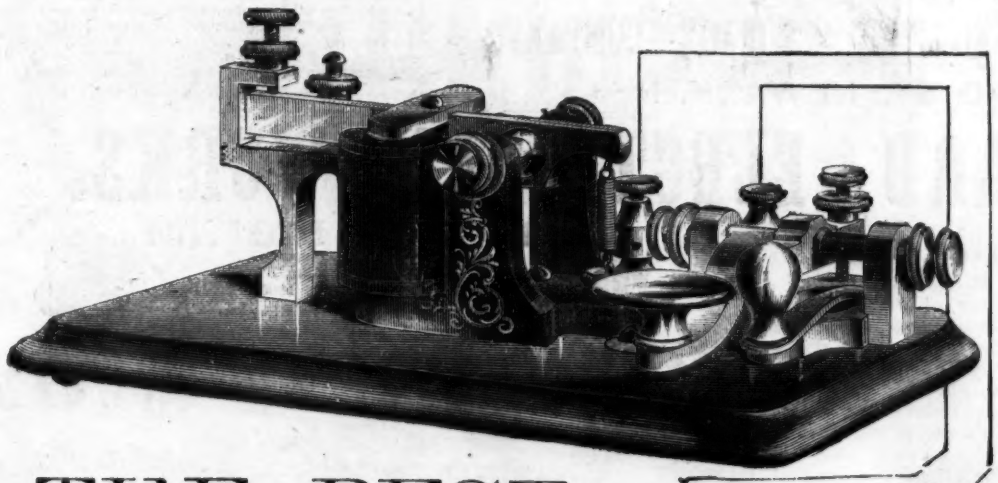

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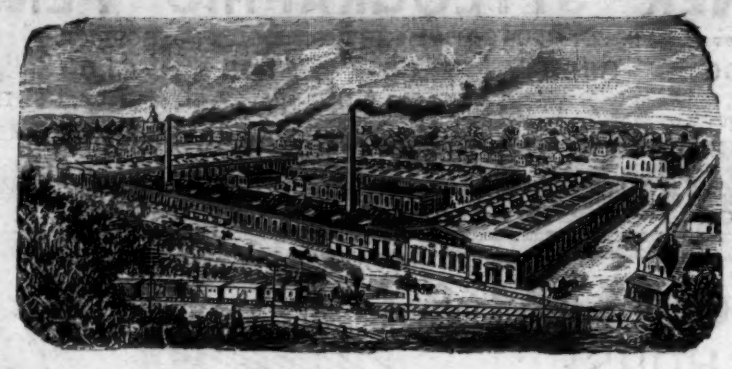

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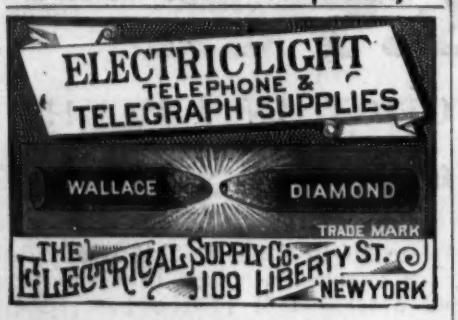

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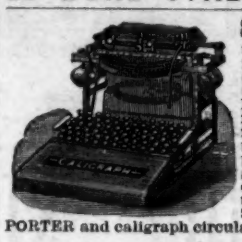

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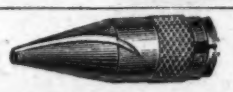

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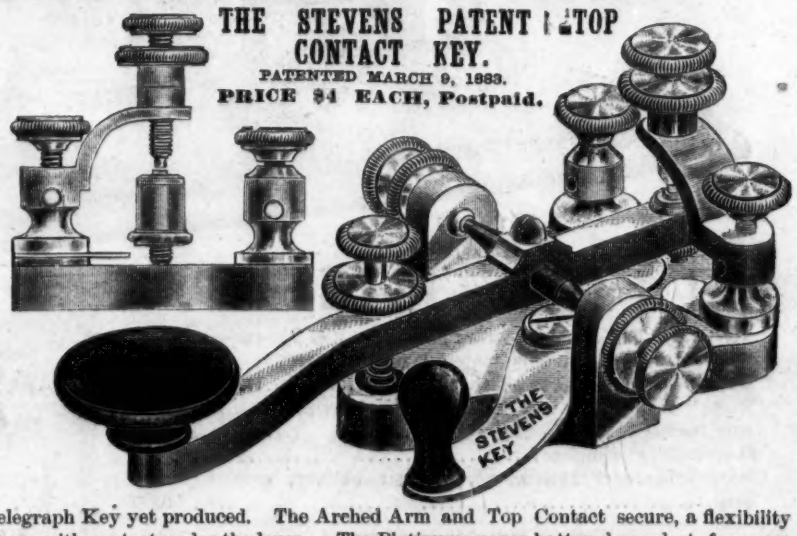

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